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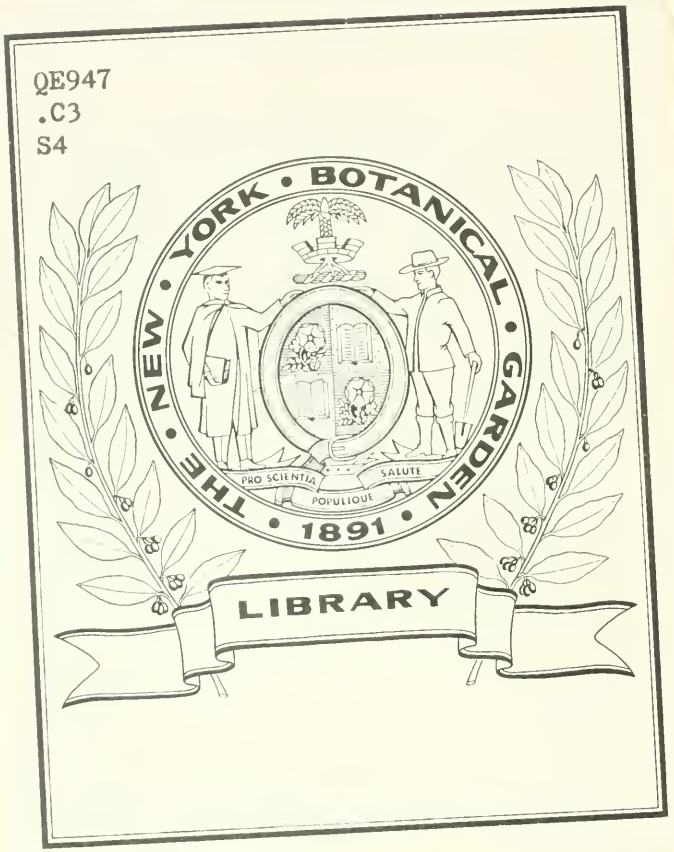
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ANNALS

OF THE

SOUTH AFRICAN MUSEUM.

VOLUME IV. containing:—

DESCRIPTIONS OF THE PALÆONTOLOGICAL MATERIAL COLLECTED BY THE MEMBERS OF THE GEOLOGICAL SURVEY OF CAPE COLONY.

PART I. *containing:—*

1. *Fossil Floras of Cape Colony.* With Fourteen Plates, and Eight Text-figures. By A. C. SEWARD, F.R.S., *University Lecturer in Botany, and Fellow of Emmanuel College, Cambridge.*

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ANNALS

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SOUTH AFRICAN MUSEUM.

I.—*Fossil Floras of Cape Colony.*—By A. C. Seward, F.R.S., *University Lecturer in Botany and Fellow of Emmanuel College, Cambridge.*

Plates I.–XIV., Text-figures 1–8.

I.—*FLORA OF THE UITENHAGE SERIES.*

I.—INTRODUCTION.

The Uitenhage plants submitted to me for examination by the Geological Commission of Cape Colony were collected from rocks exposed in the valleys of the Bezuidenhout, Witte, Sunday, and Zwartkop Rivers in the Uitenhage and Port Elizabeth districts in the south-east of Cape Colony; and from the neighbourhood of Herbertsdale, Mossel Bay; and Heidelberg.

In their 'Report on parts of the Uitenhage and Port Elizabeth Divisions,'* Messrs. Rogers and Schwarz mention the following localities from which fossils were obtained:—

1. *Zwartkop River*, between the town of Uitenhage and the mouth of the river.
2. *Bezuidenhout River*, from Blauw Krantz to the Sunday River.
3. *Witte River*, from Enon to the Sunday River.
4. *Sunday River*, between Dunbrodie and Addo Station.

* Rogers and Schwarz (01).

The Uitenhage series in the district of that name is described as including the three following divisions in descending order:—

a. The Sunday River marine beds containing animal fossils.

b. The Wood-bed with remains of fossil wood, ferns, and cycads.

c. The Enon conglomerate beds.

In 1867 Tate read a paper before the Geological Society of London 'On some Secondary Fossils from South Africa,'* in which he described several species of plants collected by Drs. Rubidge and Atherstone from rocks to which the author of the paper applied the term Uitenhage series. The majority of Tate's type-specimens are now in the Museum of the Geological Society at Burlington House, and I take this opportunity of expressing my thanks to the Council for allowing me to borrow several of Tate's plants for purposes of examination and redrawing. Four of Tate's type-specimens are represented in pl. v., figs. 1, 3, 4, 5.

The Uitenhage flora, as described in the paper of 1867, comprises the species enumerated in the following list. My examination of the original specimens, and a comparison of them with the more abundant, and in many cases more satisfactory, material recently collected have led me to make several alterations in Tate's nomenclature; the names used by Tate are given in the left-hand column and opposite each of his names I have added in the right-hand column the designations adopted in the present paper.

Tate (1867).	Seward (1903).
Palæozamia (*Otozamites*) *recta* Tate. Tate's pl. v., figs. 7*a*, 7*b*.	*Zamites recta* (Tate).† Pl. iii.; pl. vi., figs. 8–12.
Palæozamia (*Podozamites*) *morrisii* Tate. Pl. v., fig. 4.	*Zamites morrisii* (Tate). Pl. v., fig. 4. (Type-specimen of Tate, Museum of Geological Society, No. 11,108.)
Palæozamia rubidgei Tate. Pl. v., figs. 3*a*, 3*b*.	*Zamites rubidgei* (Tate). Pl. v., fig. 3. (Type-specimen of Tate, Mus. Geol. Soc., No. 11,109.)
Palæozamia (vel *Pterophyllum*) *africana* Tate. Pl. v., fig. 5.	*Zamites africana* (Tate). Pl. v., fig. 5. (Type-specimen of Tate, Mus. Geol. Soc., No. 11,110.)

* Tate (67).

† In cases where the generic designation has been altered I have followed the convenient rule of enclosing the name of the author of the species in brackets.

Tate (1867).	Seward (1903).
Pecopteris atherstonei Tate. Pl. v., fig. 2*a*, 2*b*.	*Cladophlebis denticulata* (Brongn.) forma *atherstonei*. Pl. vi., figs. 16, 17.
Pecopteris rubidgei Tate. Pl. v., figs. 1*a*, 1*b*.	*Cladophlebis denticulata* (Brongn.) forma *atherstonei*.
Pecopteris africana Tate. Pl. vi., figs. 1*a*, 1*b*.	*Cladophlebis denticulata* (Brongn.) forma *atherstonei*.
Asplenites lobata Old.	*Cladophlebis browniana* (Dunk.) Pl. ii., figs. 1–4, 6.
Sphenopteris antipodum Tate. Pl. vi., fig. 3.	*Onychiopsis mantelli* (Brongn.). Pl. i.; pl. v., fig. 1. Tate's type-specimen refigured, pl. v., fig. 1. (Mus. Geol. Soc., No. 11,114.)
Cyclopteris jenkinsiana Tate. Pl. vi., fig. 4.	*Cycadolepis jenkinsiana* (Tate). Pl. iv., figs. 3–6. Text-figure 2.
"Portions of a Coniferous stem closely allied to *Athrotaxites indicus* Old."	*Brachyphyllum* sp. Pl. vi., figs. 13, 18.
"Parts of stems . . . probably Cycadaceous."	*Benstedtia* sp. Pl. v., fig. 2. Text-figure 5.
"Ovules of *Palæozamia*."	*Carpolithes* sp.
"The under surface of the base of a cone, perhaps the same" [*Palæozamia*].	*Araucarites rogersi* sp. nov. Pl. vi., figs. 4–7.

The Uitenhage series is described by Tate as Jurassic in age; he compares the Cycads with species from the Inferior Oolite plant-beds of the Yorkshire coast, and considers two of the *Pecopteris* species as closely allied to *P. indica* from the Upper Gondwana beds of the Rajmahal Hills. In 1856 Sharpe * described several species of Mollusca from the Secondary rocks of the Sunday and Zwartkop Rivers collected by Dr. Atherstone and Mr. A. G. Bain, which he found to resemble most nearly species from the middle and lower part of the Oolitic series. The Jurassic age of the Uitenhage series is accepted by Stow † in his paper of 1871, and H. F. Blanford ‡ in 1875 referred to the flora, on the authority of Tate, as resembling that of the Rajmahal beds of India. The evidence as to geological

* Sharpe (56), p. 202. † Stow (71). ‡ Blanford (75), p. 534.

horizon furnished by species of *Trigoniæ* is regarded by Lycett * as pointing to a Cretaceous age.

In 1882, as the result of an examination of a collection of shells, Holub and Neumayr † classed the Uitenhage series as Neocomian, thus agreeing with Lycett rather than with the earlier authors. Professor Rupert Jones,‡ in an article on the Geology of South Africa, published in *Nature*, adopts Tate's opinion as to the Jurassic age of the plant-beds. The verdict of Holub and Neumayr is accepted by de Lapparent,§ who classes the Uitenhage series with a portion of the Potomac formation of the Eastern United States as Neocomian. In Oldham's edition of the 'Geology of India,' ‖ by Medlicott and Blanford, the flora of the Uitenhage series is described as "distinctly related to that of the Rajmahal Group, though the resemblances are not sufficient to establish a contemporaneity of origin." Messrs. Rogers and Schwarz, after discussing the statements of previous writers, conclude that "the only course at present open to us is to regard the age of the Uitenhage series as Upper Jurassic." ¶

The evidence afforded by the collection of plants described in the following pages—a collection rich in specimens but comparatively poor in species—points to a Wealden rather than to a Jurassic age: but this question is dealt with at greater length in the sequel.

II.—DESCRIPTION OF SPECIMENS.

Group **FILICALES.**

Family POLYPODIACEÆ.

Genus ONYCHIOPSIS Yokoyama.

This genus was instituted by Yokoyama,** a Japanese author, for a species originally described by Geyler †† from the valley of Tetorigawa in the Province of Kaga, Japan, as *Thyrsopteris elongata*.

* Lycett (79), p. 229.
† Holub and Neumayr (82). See also Neumayr (87), ii., p. 330.
‡ Jones (84), p. 554. § de Lapparent (00), p. 1267.
‖ Medlicott and Blanford (93), p. 205.
¶ Rogers and Schwarz (01), p. 17.
** Yokoyama (89), p. 26. †† Geyler (77), p. 224.

The use of the name *Thyrsopteris* as a generic designation for fossil ferns has unfortunately been adopted by several authors solely on the ground of a resemblance between the fragments of sterile fronds with those of the single existing species, *Thyrsopteris elegans*, a type confined to the island of Juan Fernandez. Yokoyama's discovery of fertile pinnæ of Geyler's species exhibiting a striking resemblance to those of the recent genera *Onychium* and *Gymnogramme*, led him to suggest the name *Onychiopsis* as a convenient designation for ferns possessing the *Onychium* type of fertile frond.

Onychiopsis mantelli Brongn.

Plate I.

Plate V., fig. 1.

1824. *Hymenopteris psilotoides* Stokes and Webb, Trans. Geol. Soc., [ii.] vol. i., p. 423, pl. xlvi., fig. 7.
1828. *Sphenopteris Mantelli* Brongniart, Prodrome, p. 50.
1828. *Sphenopteris Mantelli* Brongniart, Hist. vég. foss., p. 170, pl. xlv., figs. 3–7.
1833. *Sphenopteris Mantelli* Mantell, Geol. S.E. England, p. 241.
1836. *Cheilanthites Mantelli* Göppert, Foss, Farrnkrt., p. 231; Nova Acta Ac. Caes. Leop.-Car., vol. xvii. Supp.
1839. *Cheilanthites denticulatus* Roemer, Verstein. Ool.-Geb., p. 9, pl. xvii., fig. 1.
1846. *Sphenopteris Mantelli* Dunker, Wealdenbildung, p. 2, pl. i., fig. 4*a*.
1846. *Sphenopteris Roemeri* Dunker, *loc. cit.*, p. 3, pl. i., figs. 3, 4, 5.
1846. *Sphenopteris tenera* Dunker, *loc. cit.*, pl. viii., fig. 5.
1846. *Confervites fissus* Dunker, *loc. cit.*, pl. i., fig. 1.
1852. *Sphenopteris Mantelli* Ettingshausen, Abh. k.-k. geol. Reichs., p. 14, pl. iv., figs. 3, 4.
1867. *Sphenopteris antipodum* Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 139.
1869. *Sphenopteris* (*Davallioides*) *Mantelli* Schimper, Trait. pal. vég., vol. i., p. 393.
1871. *Sphenopteris Mantelli* Schenk, Palæontographica, vol. xix., p. 208, pl. xxiii., figs. 1–8.
1871. *Sphenolepis Kurriana* Schenk, pl. xxv., fig. 6, *loc. cit.*, p. 243, pl. xxxviii., fig. 2.
1875. *Sphenopteris Mantelli* Schenk, Palæontographica, vol. xxxiii., p. 158, pl. xxviii., fig. 12.

1877. *Thyrsopteris elongata* Geyler, Palæontographica, pl. xxx., fig. 5, pl. xxxi., figs. 4, 5.
1878. *Sphenopteris Roemeri* Dupont, Bull. Ac. R. Belg., vol. xlvi., [ii.] p. 396.
1881. *Sphenopteris Mantelli* Heer, Secc. Trab. Geol. Portugal, 1881, p. 12, pl. xi., figs. 1–5; pl. xii., figs. 2*b* and 2*bb*.
1881. *Sphenopteris valdensis* Heer, *loc. cit.*, p. 14, pl. xv., figs. 9, 10, and 13; pl. xvi., fig. 5*b*. (The other figures are doubtful.)
1889. *Sphenopteris Mantelli* Fontaine, Potomac Flora, p. 91, pl. i., figs. 1 and 2.
1889. *Onychiopsis elongata* Yokoyama, Journ. Coll. Sci. Imp. Univ. Japan, vol. iii., pl. i., p. 27; pl. ii., figs. 1–3; pl. iii., fig. 6*d*; pl. xii., figs. 9, 10.
1890. *Onychiopsis elongata* Nathorst, Denksch. k. Ak. Wiss. Wien, pl. ii., fig. 6; pl. v., fig. 3; pl. vi., fig. 5.
1894. *Onychiopsis elongata* Yokoyama, Journ. Coll. Sci. Univ. Japan, vol. vii., pt. iii., p. 215; pl. xx., fig. 8; pl. xx., figs. 1, 4.
1894. *Sphenopteris* (*Davallia*) *Mantelli* Saporta, Flor. Portugal, pl. xiii., figs. 5, 6; pl. xxiii., figs. 1, 2; pl. xxviii., fig. 2; pl. xxix., fig. 1; pl. xxx., figs. 9, 10; pl. xxxi., figs. 1, 2.
1895. *Sphenopteris Mantelli* Ward, Potomac Form. p. 392.
1896. *Onychiopsis Mantelli* Ward, Lower Cret. Europe and America, p. 483.
1896. *Onychiopsis elongata* Ward, *ibid.*

The following definition of *Onychiopsis mantelli* is quoted from the first part of the Catalogue of Wealden Plants in the British Museum.* The fertile segments represented in the English specimens have not so far been found in the South African material. "Frond tripinnate, ovate lanceolate, rachis winged and prominent; pinnæ lanceolate, alternate, approximate, given off from the main rachis at an acute angle. Pinnules alternate, narrow, lanceolate acuminate, uninerved, of nervation type *Cœnopteridis;* the larger ones serrate and gradually passing into pinnæ, with narrow ultimate segments."

["Fructification in the form of sessile or shortly stalked linear ovate segments with rugose surfaces, and terminating usually in a very short awn-like apical prolongation."]

The name *Sphenopteris mantelli* was substituted by Brongniart †

* Seward (94), p. 43.

† Brongniart (28), p. 50; (28²) p. 170.

for *Hymenopteris psilotoides*, formerly used by Stokes and Webb* for fragments of a fern from the English Wealden. In 1894 the discovery of several fertile pinnæ demonstrated the close relationship of the species to the Japanese fern described by Yokoyama as *Onychiopsis elongata* (Gey.). The material from South Africa is unfortunately represented solely by sterile fronds, and we are therefore unable to found a complete specific diagnosis on the Uitenhage specimens. It is as a rule inadvisable to employ a generic name implying relationship with existing types unless the comparison is supported by the evidence of fructification characters. It must be admitted that so long as we have only sterile examples before us there necessarily remains an element of doubt as to the correctness of our interpretation of the specimens. In the present case there is so close a resemblance as regards the habit of the fronds and in the form of the ultimate segments between the Uitenhage plant and such European species as *Onychiopsis mantelli* (Brongn.),† *O. capsulifera* (Vel.),‡ and the Japanese type, *O. elongata* (Gey.),§ that I have ventured to adopt Yokoyama's generic name *Onychiopsis*.

The fern figured by Tate as *Sphenopteris antipodum* has been referred to in a previous work as apparently identical with the European specimens of *Onychiopsis mantelli*.‖ The drawing of Tate's type-specimen,¶ reproduced in pl. v., fig. 1, shows rather more clearly than the figure published in 1867 the identity of *Sphenopteris antipodum*, at least as regards sterile pinnæ, with *Onychiopsis mantelli*. In Part I. of the Catalogue of Wealden plants in the British Museum I figured a fragment of a frond as *Onychiopsis elongata*, retaining Geyler's specific name as characterising a type of frond with pinnules of slightly greater breadth than those of *Onychiopsis mantelli*; the separation of the two species was, however, made with some hesitation and with the admission that both forms might eventually have to be included under one term.** Since the publication of the Catalogue a much larger and more complete specimen of *Onychiopsis* has been obtained from the Wealden beds of Sussex with pinnules of slightly broader type, which confirms my suspicion that the recognition of two distinct species was based on insufficient evidence.

The plant figured by Geyler in 1877 as *Thyrsopteris elongata*, and

* Stokes and Webb (24), p. 423.
† Seward (94), p. 41, pl. ii.
‡ Velenovsky (88), pl. i., figs. 6–12.
§ Geyler (77), pl. xxx., xxxi.
‖ Seward (94), p. 44.
¶ Museum of the Geological Society of London, No. 11,114.
** Seward (94), p. 55, pl. ii., fig. 2.

afterwards described and illustrated more fully by Yokoyama as *Onychiopsis elongata*, is spoken of by the latter author as the chief characteristic fossil of the Japanese Flora of Kaga, Hida, and Echizen, which is referred to the Bathonian stage of the Inferior Oolite. Fragments of the same type are figured by Yokoyama, also from the plant-beds of Kozuke, Kü, Awa, and Tosa referred to the Neocomian series.* The Japanese type differs from the European *Onychiopsis mantelli* in its slightly broader segments, but the difference is hardly enough to warrant a specific separation. The fact that both forms possessed the same type of fertile pinnæ demonstrates their close relationship, and such small differences as are exhibited by the sterile fronds are not greater than analogous variations met with in species of existing ferns.

The specimens figured by Nathorst † from the province of Tosa, in Japan, are undoubtedly specifically identical with Geyler's species, and I believe also with the Uitenhage plant.

Reference is made in the synonomy to the figures of *Onychiopsis mantelli*, published by Schenk and other authors from European Wealden rocks; it is unnecessary therefore to do more than draw attention to the abundance of this well-marked type in Wealden floras. The same species is recorded also by Fontaine ‡ and Ward § from the Potomac formation of North America; some of the ferns referred by the former author to *Thyrsopteris*, without a fragment of a fertile pinna to justify the assumed relationship with the recent genus of Cyatheaceæ, are in all probability identical with *Onychiopsis mantelli*. We may quote *Thyrsopteris rarinervis*, *T. insignis*, *T. microphylla* as examples of Fontaine's species which bear a close resemblance to *Onychiopsis mantelli*.|| A fern described by Heer as *Asplenium dicksonianum*¶ from the Kome beds of Greenland, if not identical with the Uitenhage species, is probably a closely allied type. In the late Marquis of Saporta's monograph on the Mesozoic Floras of Portugal,** *Onychiopsis mantelli* is recorded from several localities as *Sphenopteris* (*Davallia*) *mantelli*, but the evidence on which a relationship to *Davallia* is founded seems to me inadequate; Saporta speaks of the species as a characteristic Wealden fern, but fragments found in somewhat older beds point to the existence of

* Yokoyama (94), p. 215, pl. xx., xxi.
† Nathorst (90), pl. ii., fig. 6; pl. v., fig. 3; pl. vi., fig. 5.
‡ Fontaine (89), pl. i. § Ward (95), p. 392; (96), p. 483.
|| Fontaine (89), pl. xlii., xliii., xliv., xlv.
¶ Heer (75), pl. i., figs. 1–5.
** Saporta (94), pl. xiii., xxiii., xxviii.–xxxi.

the same type before the close of the Jurassic period. It is noteworthy, however, that the specimens from the Jurassic localities are very small, and several of them can hardly be referred with confidence to *Onychiopsis mantelli*, which is represented by many undoubted examples from the Wealden of Portugal as demonstrated by the figures of Heer * and Saporta.

Plate I., fig. 1 (428c).

Portion of a large frond, approximately 17 cm. in length, with long spreading pinnæ. The slender rachis shows narrow lateral wings, and in places a prominent woody axis; the pinnæ are decurrent on the rachis, and the upper branches of the frond are given off at a smaller angle than the lower. Longest pinnæ 8 cm. long, tapering gradually to a serrate acuminate apex. Veins obscure. Specimen 434a is the reverse of 428c.

Plate I., fig. 2 (391c), 1½ nat. size.

A single pinna bearing in the lower part linear serrate pinnules, and in the apical region shorter entire segments. The specimen from which the drawing was made differs from the frond represented in fig. 1 in its slightly narrower and more delicate pinnules, and is identical with the typical European examples of the species.

Plate I., fig. 3 (407c), x 2.

The complete specimen of which a small portion is represented in the figure, twice natural size, is 8 cm. in length, and agrees in all respects with the English and German form of *Onychiopsis mantelli*. The single pinna shows the entire and shorter segments characteristic of the apical region of a frond.

Plate I., fig. 4 (401c), x 2.

A portion of the rachis and the base of two pinnæ illustrating the broader type of lobed pinnules. This fragment shows very clearly the winged character of the rachis and the prominent woody axis.

Plate V., fig. 1. (Type-specimen of Tate's *Sphenopteris antipodum*; Museum of Geological Society of London, No. 11,114.)

This specimen from Geelhoutboom is, I believe, clearly identical with *Onychiopsis mantelli* (Brongn.), at least as regards the vegetative characters of the frond. The rachis is traversed by a narrow

* Heer (81), pl. xi., xii.

woody axis with lateral wings, and gives off spreading pinnæ bearing slender linear segments the lamina of which is divided into acuminate teeth.

Other Specimens: 433c.—This specimen shows very clearly the narrow pinnæ with entire segments (*cf.* fig. 3) in the apical region of the frond; also the gradual transition from the narrow oval segments to larger segments with a serrate margin. 140c, 320c (on the reverse side is a good impression of a *Cycadolepis jenkinsiana*), 389c, 390c (with seeds of *Araucarites rogersi*), 392c, 411c, 429c, 430c.

Genus CLADOPHLEBIS Brongniart.

(Of doubtful Family-position.)

Brongniart proposed this generic name in 1849 * for certain forms of *Pecopteris*, previously included in the group Neuropterides. The genus is founded on sterile fronds only, and is applied to ferns which cannot be referred to a particular family; the name *Cladophlebis* is usually made use of for Mesozoic species which agree in habit with Palæozoic representatives of *Pecopteris*. Numerous fossil ferns have been described by authors as species of *Aspidium*, which, in the absence of sori or sporangia, have no claim to be designated by the name of a recent genus.

Cladophlebis browniana (Dunk.).

Plate II., figs. 1–4, 6.

1846. *Pecopteris Browniana* Dunker, Wealdenbildung, p. 5, pl. viii., fig. 7.
1849. *Pecopteris Browniana* Brongniart, Tableau, p. 107.
1852. *Alethopteris Reichiana* Ettingshausen, Abh. k.-k. geol. Reichs., vol. i., Abth. iii., No. 2, p. 17.
1871. *Pecopteris Browniana* Schenk, Palæontographica, vol. xix., p. 215, pl. xxvi., figs. 2, 2*a*.
1877. *Pecopteris exiliformis* Geyler, Palæontographica, vol. xxiv., p. 226, pl. xxx., fig. 1.
1889. *? Pecopteris Browniana* Fontaine, Potomac Flora, pl. xxiii., figs. 2–7.

* Brongniart (49), p. 25.

1890. *Pecopteris Geyleriana* Nathorst, Denkschr. k. Ak. Wiss. math.-nat. Cl., vol. lvii., p. 48, pl. iv., figs. 2–6.
1890. *Pecopteris* cf. *Browniana*, *ibid.*, pl. v., fig. 5.

Frond bipinnate, passing in the lower part of the frond to tripinnate. Rachis comparatively broad and strong, from which linear pinnæ, tapering to an acuminate apex, are given off at a wide angle. Pinnules short and broad, attached by the whole broad base to the axis of the pinna; the lower margin strongly arched, the upper face almost straight or slightly concave. A well-marked midrib from which spring a small number of secondary veins at a wide angle. The pinnules are for the most part entire, passing in the lower pinnæ into lobed or even pinnate segments.

The Uitenhage specimens include numerous examples of bipinnate and tripinnate fronds which were referred by Tate in his paper of 1867 * to a species previously figured by Oldham † from the Rajmahal Hills of Bengal as *Pecopteris* (*?*) *lobata*. A comparison of the fragments represented in pl. ii., figs. 1–4 and 6, with the specimen figured by Oldham reveals a very close resemblance, which, as Tate suggested, may amount to specific identity. On the other hand, there is, I think, an even closer agreement between the Uitenhage fern and that described from European Wealden strata as *Cladophlebis dunkeri* (Schimp),‡ a form originally named by Dunker in 1846 *Pecopteris polymorpha*.§ The fern named by Dunker *Pecopteris browniana* ‖ differs in no essential features from *Cladophlebis dunkeri*, and a re-examination of specimens from the Wealden beds of the Sussex coast leads me to give up my previously expressed opinion that both specific names should be retained. The difference between the fragment represented in pl. vii., fig. 4, of my 'Wealden Flora,' Part I., and that shown in pl. vii., fig. 3,¶ is, I think, not more than may be found on a single frond of the same species. Seeing that the name *browniana* was established before the specific name *dunkeri*, it should be employed in preference to Schimper's designation.

The accurate separation of sterile fronds of the type represented in pl. ii., figs. 1–4, 6, is a hopeless task; among recent ferns this form of leaf recurs in several genera, and in the absence of fertile

* Tate (67), p. 146.
† Oldham and Morris (63), pl. xxviii.–xxx.; Feistmantel (77), pl. xxxvi., fig. 3.
‡ Seward (94), p. 101, pl. vii., fig. 3.
§ Dunker (46), pl. vii., fig. 5.
‖ *Ibid.*, pl. viii., fig. 7.
¶ Seward (94).

examples it might well be impossible to arrive at a generic much less specific determination.

So far as vegetative characters are concerned, the fern described by Yokoyama from Japan as *Pecopteris browniana* * appears to be identical with the South African plant; a frond of very similar if not identical form is figured by the same author from a somewhat lower horizon as *Pecopteris exilis* Phill.,† an Inferior Oolite species since placed in the genus *Klukia*.‡ Nathorst has also figured portions of fronds from Japan which he regards as probably identical with his species *Pecopteris geyleriana*. It is, however, not improbable that the specimens represented in his pl. iv., figs. 2, 6, are specifically distinct from the type-specimen of *P. geyleriana*;§§ be that as it may, I am unable to distinguish the two examples shown in Nathorst's figs. 2 and 5 from the Uitenhage fern. In addition to the records of ferns believed to be identical with *Cladophlebis browniana* mentioned in the above synonomy, there are others which may be referred to as presenting a close resemblance possibly amounting in some cases to specific identity.

Reference has already been made to Oldham's Indian species *Pecopteris lobata*, as a fern with the same form of frond as that of *Cladophlebis browniana*; the specimen figured by Feistmantel as *Dicksonia* (*Sphenopteris*) *bindrabunensis* ‖ may perhaps represent the fertile form of *Pecopteris lobata*. *Dicksonia coriacea*, a Chinese species recorded by Schenk affords another example of the *C. Browniana* form of frond.¶ Some of the fragments figured by Saporta ** from Neo-Jurassic rocks of Portugal may be identical with the African plant, and a comparison may also be made with *Aspidium heterophyllum* and *Cladophlebis distans* †† described by Fontaine from the Potomac beds. *Aspidium montanense* figured by the same author ‡‡ from the Great Falls of Montana represents another very similar species.

Another fern of precisely similar habit to *Cladophlebis browniana* and hardly distinguishable from it is a species recently placed in the genus *Coniopteris*, on the evidence of fertile specimens, but originally described as *Neuropteris aryuta* L. and H.§§ This Inferior

* Yokoyama (94), p. 218, pl. xxiv., figs. 2, 3; pl. xxvii., figs. 1–5.
† *Ibid.* (89), pl. i., figs. 8–10.
‡ Raciborski (91).
§ Nathorst (90).
‖ Feistmantel (77), pl. xxxvii., fig. 2.
¶ Schenk (83), pl. lii., figs. 5, 6.
** Saporta (94), pl. vi., fig. 1; pl. vii., fig. 5; pl. xi., xii.
†† Fontaine (89), pl. xiii., figs. 4, 5; pl. xv., figs. 1–5.
‡‡ *Ibid.* (92), pl. lxxxii., lxxxiii., and lxxxiv.
§§ Seward (00[2]), p. 115, pl. xvi., xvii.; Lindley and Hutton (34), pl. cv.

Oolite species probably belongs to the Cyatheaceæ, but in view of the frequent occurrence of this type of frond in different genera of recent ferns it is unsafe to assume that the South African type possessed sori and fertile segments like those of the Inferior Oolite species.

Plate II., figs. 1, 1*a* (343c).

The apical portion of a frond bearing linear and slightly falcate pinnæ with short and broad pinnules and entire apices. The venation is more accurately shown in fig. 1*a*; the enlarged drawing also illustrates the incomplete separation of the pinnules as contrasted with their more complete separation in the lower pinnæ.

Plate II., figs. 2, 2*a* (344c).

Similar to fig. 1, but showing more clearly the comparatively stout rachis; the pinnules represented in fig. 2*a* differ from those shown in fig. 1*a* in their more complete separation and in their greater length. The venation is clearly seen in the enlarged pinnules, also the shorter and almost deltoid form of the basal pinnule on the lower side of the pinna.

Plate II., fig. 3 (364c).

The specimen, of which a small piece is represented in the figure, consists of fairly large portions of fronds similar to that drawn in fig. 4. Fig. 3 illustrates the attachment of a pinna to the rachis, also the longer type of pinnule—4·5 mm.—characteristic of the lower branches of a frond.

Plate II., figs. 4, 4*a*, 4*b* (342c).

The rachis has a length of 7 cm., and the longest pinna 4·5 cm. This specimen shows very clearly the characteristic habit of the frond; the stout rachis giving off opposite or alternate pinnæ of linear acuminate form with falcate segments, most of which have entire margins (fig. 4*a*), while others (fig. 4*b*) in the lower part of the leaf show signs of an incipient subdivision of the lamina into rounded lobes—a condition exhibited in a more pronounced form in fig. 6.

On the same piece of rock is an impression of a piece of *Benstedtia*, and on the reverse side a portion of the rachis of *Zamites recta* shown in pl. iii., fig. 1.

Plate II., fig. 6 (361c).

A portion of a pinna, slightly enlarged, from a lower part of a frond than the pinnule outlined in fig. 4*b*.

Other Specimens: 339c, 340c, 349c, 350c, 351c, 358c, 359c, 363c, 366c, 369c, 373c.

Cladophlebis denticulata (Brongn.), forma atherstonei.

Plate VI., figs. 16, 17.

1867. *Pecopteris Atherstonei* Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 145, pl. v., figs. 2*a*, 2*b*.
1867. *P. Rubidgei*, *ibid.*, p. 146, pl. v., figs. 1*a*, 1*b*.
1867. *P. africana*, *ibid.*, p. 146, pl. vi., figs. 1*a*, 1*b*.

Frond bipinnate, rachis broad, giving off pinnæ at a wide angle; the branches or pinnæ bear crowded linear pinnules attached by the whole of the broad base to the comparatively broad axis; the linear pinnules reach a length of slightly over 3 cm., apices bluntly pointed; midrib strong, giving off secondary veins at a wide angle, which branch dichotomously as they pass obliquely upwards to the edge of the lamina. Fertile pinnules unknown in the South African form.

The most abundant plant in the material collected two miles east of Herbertsdale is a fern characterised by linear pinnules of the *Cladophlebis* type, which, owing in part to the friable nature of the rock, is seldom preserved except in small broken pieces of pinnæ. Fragments of *Tæniopteris* fronds (pl. ii., fig. 5) are constantly found in association with this form of *Cladophlebis*. The piece represented in fig. 16, pl. vi., shows the venation very clearly preserved, and with fig. 17 illustrates the form of the pinnules. There can be no doubt that this fern is the one named by Tate *Pecopteris atherstonei;* an examination of Tate's type-specimens leads me to regard the smaller form named by this author *Pecopteris rubidgei* as a fragment of the same species. In all probability we may safely include Tate's name *P. africana* as another synonym under *P. atherstonei*. No trace of sori or fertile pinnæ has been found, and we must therefore be content to leave the plant as a member of the Filices of uncertain family position. As regards the question of nomenclature: there is no more common type of fern frond among recent genera than that of the bipinnate leaf with linear pinnules, attached by the

whole of the base to the pinna-axis, like those represented in figs. 16 and 17, pl. vi. Among existing species we find it in *Onoclea germanica* W., *Alsophila junghuhiana* Mett., *Cyathea dealbata* Sw., *Gleichenia glauca* Sw., *Sadleria cyatheoides* Kaulf., *Pteris arguta* Ait., *Todea barbara* Moore, also in species of *Polypodium*, *Asplenium*, and other ferns. In previous publications dealing with Mesozoic floras I have drawn attention to the wide geographical range of a similar type of frond during the Rhætic, Inferior Oolite, and Wealden periods.* The form named by Brongniart *Pecopteris denticulata* and now placed in the genus *Cladophlebis* occurs as an element of Jurassic floras in all parts of the world. Fertile pinnæ are rarely found, and none that have come under my observation show recognisable sporangia, but attention has elsewhere been drawn to the close resemblance—as regards the form of the sori and their distribution on the lamina—between some English specimens and fertile pinnæ of *Todea barbara*.† This resemblance is, however, insufficient to serve as a safe guide to affinity, and all that we can say is that it is not improbable that some at least of the fronds of the type represented by *Cladophlebis denticulata* may be members of the Osmundaceæ. In a previous work, before the possible relationship to the Osmundaceæ occurred to me, I included *Cladophlebis denticulata* as a doubtful member of the Polypodiaceæ. A fertile specimen of *Todea australis* (Morr.) from Australia was found sufficiently well preserved to enable Renault ‡ to examine the sporangia, which he describes as agreeing closely with those of recent Osmundaceæ.

It is obviously impossible to discriminate between the numerous sterile fragments of this form of frond from various geological horizons, ranging from Rhætic to Lower Cretaceous, and furnished by rocks extending from Greenland to Australia and New Zealand, at least so far as concerns the recognition of distinctive characters that could reasonably be considered of specific rank. A possible method to adopt is to use the term *Cladophlebis denticulata* (Brongn.) as a comprehensive title for ferns, for the most part of Jurassic age, characterised by bipinnate fronds with linear ultimate segments of the shape and with the venation characters shown in figs. 16, 17, pl. vi. We may in particular cases employ a second name, as denoting a possible variety or form and as an index of locality. In the present instance we may therefore speak of the Herbertsdale

* Seward (94), p. 95; (00), p. 18; (00[2]), p. 134.

† Seward and Ford (03).

‡ Renault (83), p. 81, pl. xi.

fern as *Cladophlebis denticulata* forma *atherstonei*. The epithet *denticulata* may in some instances prove misleading, but the presence or absence of fine denticulations is in itself hardly a character of primary taxonomic value. Moreover, in imperfectly preserved specimens so small a point is not easy to determine. The figures of English East Yorkshire specimens * of Brongniart's type bear a very close resemblance to the fragments of the South African plant; similarly *Pecopteris indica* O. and M.† from the Rajmahal series of Bengal, *Asplenium argutulum* Heer, from China,‡ Fontaine's *Cladophlebis oblongifolia* from the Potomac formation,§ *Pteris frigida* and *P. longipennis* Heer,‖ and *Cladophlebis stewartiana* Hartz ¶ are some of the many examples of fern fronds that might well be grouped under *Cladophlebis denticulata*.

The following list serves to illustrate the geological and geographical range of ferns comparable with, and no doubt in part identical with, Brongniart's Inferior Oolite type. The references to authors are given in full in the Bibliography.

Names employed by Authors quoted.	Geographical range.	Approximate geological horizon.	Author.
Cladophlebis denticulata ..	England (E. Yorks)	Jurassic	Seward (00) (00²)
Pecopteris indica	India (Bengal)	Jurassic	Oldham & Morris (63)
Cladophlebis stewartiania	Greenland	Jurassic	Feistmantel (77) Hartz (96)
Pteris frigida	Greenland	Lower Cretaceous	Heer (82)
P. albertini	Bohemia	Lower Cretaceous	Frič and Bayer (01)
Cladophlebis oblongifolia ..	Eastern N. America	Wealden—Upper Jurassic	Fontaine (89)
Asplenium distans	Canada (Rocky Mountains)	Lower Cretaceous	Dawson (85)
Asplenium argutulum	China	Jurassic	Schenk (83)
Alethopteris australis	Australia	Jurassic	Feistmantel (90)
Polypodium hochstetteri ..	New Zealand	Wealden?	Unger (64)
Asplenium distans	Japan	Jurassic	Yokoyama (89)
Cladophlebis denticulata ..	Poland	Jurassic	Raciborski (94)

Plate VI., figs. 16, 17 (170d).

The specimen shown in fig. 16 is one of several fragments of pinnæ bearing linear pinnules approximately 3 cm. in length. The distal portion of the pinnule represented in fig. 17 illustrates the form of the apex which is not seen in fig. 16. The Herbertsdale

* Seward (00), pl. xiv., xv., xx.
‡ Schenk (83), pl. xlvi.–xlviii., lii.
‖ Heer (82), pl. x.–xiii.
† Oldham and Morris (62), pl. xxvii.
§ Fontaine (89), pl. vii., figs. 3–5.
¶ Hartz (96), pl. xi.

rock, in which this fern is very abundant, contains also numerous fragments of *Tæniopteris* fronds and pieces of stems or probably broad rachises.

Other Specimens: 173d, several imperfect portions of pinnæ and pinnules, also a piece of what is probably a broad rachis or petiole: with fragments of *Tæniopteris*. 178d, 179d, 185d, 357c, smaller pinnules slightly larger than 1 cm., 368c smaller pinnules with clearly marked venation, A.

Genus SPHENOPTERIS Brongniart.

Sphenopteris fittoni Sew.

Plate II., figs. 7, 8.

1836. *Sphenopteris gracilis* Fitton, Trans. Geol. Soc., vol. iv., ser. ii., pt. ii., p. 103.
1849. *Pachypteris gracilis* Brongniart, Tableau, p. 107.
1852. *Pachypteris gracilis* Ettingshausen, Abh. k.-k. Geol. Reichs., vol. i., Abth. iii., No. 2, p. 24.
1864. *Asplenium palæopteris* Unger, Reise Fregatte Novara, vol. i., Abth. ii., p. 3, pl. i., fig. 4.
1893. *? Sphenopteris delgadoi* Saporta, Rev. Gén. Bot., vol. v., 1893, p. 270, pl. iv., fig. 5.

Frond ovate lanceolate, bipinnate, possibly becoming tripinnate in the lower part; pinnæ linear acuminate, alternate, springing at a wide angle from the rachis; pinnules ovate acuminate with entire margins passing gradually into more or less deeply lobed segments obliquely attached to the axis of the pinna on which their lower margin is decurrent. Venation of the *Sphenopteridis* type.

The specimen on which this species is founded was described in 1827 by Fitton from the English Wealden rocks as *Sphenopteris gracilis*,* but before his paper was published by the Geological Society of London the specific name *gracilis* had been applied to a Carboniferous example of *Sphenopteris*. Fitton's type-specimen, now in the Museum of Practical Geology, Jermyn Street, London, is clearly identical with examples more recently found by the late Mr. Rufford on the Sussex coast near Hastings, and I have little doubt that this English fern, so far as characters based on sterile

* Fitton (36).

fronds enables me to form an opinion, agrees too closely with the Uitenhage form to justify specific separation.

The entire form of pinnule, represented in fig. 8, pl. ii., is found in the upper pinnæ of a frond, and every gradation is met with connecting the narrow segments in the apical portion of the fragment represented in fig. 8 with segments like those of fig. 8*a* and the more deeply lobed type shown in figs. 7*a*, 7*b*. In addition to the species mentioned in the above synonomy, there are various others with which *Sphenopteris fittoni* exhibits a close agreement. Of these reference may be made to *Scleropteris pomelii* and *S. tenuisecta*, figured by Saporta * from French rocks; also *Scleropteris tenuisecta* and *S. tenelliloba*, recorded by the same author from the Jurassic plant-beds of Portugal.† *Scleropteris vernonensis*, figured by Ward ‡ from the Potomac formation, and Fontaine's *Scleropteris virginica* § are other examples of ferns of similar habit; also *Sphenopteris plurinervia*, a Portuguese species described by Heer.‖

Plate II., fig. 7 (249c).

An imperfect and somewhat obscure piece of a frond 7·5 cm. in length, a portion of which is represented in the figure. From a broad rachis pinnæ are given off at almost a right angle. The habit of the frond is more open than in *Cladophlebis browniana*. The pinnules of *Sphenopteris fittoni* are distinguishable by their narrower and more pointed form and more acute lobes. The enlarged drawings (figs. 7*a*, 7*b*), show the form of the pinnules more clearly; the venation is obscure, but traces of a midrib can be seen here and there. On the same piece of rock occur also fragments of *Araucarites* scales and a good example of *Zamites* rachis.

Plate II., fig. 8 (376c).

A portion of a pinna with more clearly preserved pinnules differing from those shown in fig. 7 in having entire or very slightly lobed margins (fig. 8*a*). The venation is clearly seen in this specimen; it consists of a central midrib from which spring a few secondary veins at an acute angle.

Other specimens: 347c.

* Saporta (73), pl. xlvii.; (91), pl. lix.–lxi.
† *Ibid.* (94), pl. ii., iii.
‡ Ward (95), pl. ii., figs. 1–3.
§ Fontaine (89), pl. xxviii., figs. 3, 5.
‖ Heer (81), pl. xi., fig. 6.

Sphenopteris sp.

Text-figure 1.

The fragment (231c) represented in text-fig. 1 (B) is part of the terminal portion of a pinna, 2 cm. long, bearing pinnules with well-defined acutely spreading and forked veins of the *Sphenopteris* type (A). It bears a close resemblance to the type of frond illustrated by the widely distributed Jurassic species *Coniopteris hymenophylloides* (Brongn.); but without more evidence it is advisable to leave the fragment as *Sphenopteris* sp.

Other specimens : 234c, 238c.

Genus TÆNIOPTERIS Brongniart.

Tæniopteris sp. [*cf.* Tæniopteris arctica (Heer).]

Plate II., figs. 5, 5*a*.

The fragments of simple *Tæniopteris* fronds are too imperfect to admit of a satisfactory diagnosis on which to found a species. The fronds possess a broad midrib from which lateral veins are given off at right angles or at an angle slightly less than 90°; these may pass to the margin as simple veins or bifurcate either close to their exit from the midrib or in different positions in the lamina. The leaf is usually about 1·5 cm. in breadth and there appear to be approximately 10 veins per 5 mm.

No specimens have been found showing either the base or apex of the lamina, and there is no indication of any sporangia. The abundance of *Tæniopteris* in Jurassic and Wealden strata and the close agreement, often amounting to identity, between forms referred to distinct species renders it inadvisable to apply a distinctive name to the Uitenhage fragments. A comparison may be made with the

form of leaf named by Heer *Oleandra arctica* from the Cretaceous (Kome) beds of Greenland* and with specimens from the Great Falls of Montana described by Newberry† as "cf. *Oleandra arctica* Heer." The type *Tæniopteris arctica* (Heer) is perhaps the most nearly allied, as regards form and venation, to the South African leaves. The Rajmahal leaves, described originally by McClelland as *Tæniopteris spathulata*‡ and afterwards by Feistmantel as *Angiopteridium spathulatum*, § represent similar forms. The narrower leaves from the Rajmahal Hills, figured by Oldham and Morris and by Feistmantel and referred to McClelland's species, are undoubtedly identical with McCoy's *Tæniopteris daintreei*,‖ abundant in Jurassic strata of Victoria, and distinct from the Wealden Uitenhage leaves. Nathorst's species *Tæniopteris lundgreni*,¶ from Upper Jurassic beds of Advent Bay, Spitzbergen, is another type with which the African specimens may be compared.

The European Wealden species, *Tæniopteris beyrichii* Schk.,** is most probably distinct from, although comparable with, such specimens as those shown in pl. ii., figs. 5, 5*a*.

Plate II., figs. 5, 5*a* (172d, 193d).

The venation is clearly shown in the figured fragments. Similar portions of leaves occur abundantly in association with *Cladophlebis denticulata*, forma *atherstonei*, but all are imperfect. There appear to be about 10 secondary veins per 5 mm. of lamina; the average breadth of the leaf is approximately 1 cm.

Other specimens: 168d, 385c.

Group CYCADOPHYTA.

This name has recently been suggested by Nathorst†† for Cycadean plants which are known only in the form of vegetative organs and cannot be referred with certainty to either the Bennettitales or Cycadales—groups characterised by well-marked features exhibited by their reproductive organs.

* Heer (78), pl. xii., figs. 3–11.
‡ McClelland (50), pl. xvi., fig. 1.
‖ McCoy (74), pl. xiv., figs. 1, 2.
** Seward (94), p. 152, pl. ix., fig. 3.
† Newberry (91), pl. xiv., fig. 9.
§ Feistmantel (77), pl. i.
¶ Nathorst (97), pl. iii., figs. 1–5.
†† Nathorst (02).

Genus ZAMITES Brongniart.

Zamites recta (Tate).

Plate III.

Plate VI., figs. 8–12.

1867. *Palæozamia* (*Otozamites*) *recta*, Tate, Quart. Journ. Geol. Soc., vol. xxiii., pl. v., figs. 7*a*, 7*b*.

Fronds pinnate, probably reaching a length of 50–60 cm., rachis stout and woody.

Pinnæ alternate, attached obliquely in two alternating rows by a slightly narrowed and callous base to the upper face of the frond axis, in the lower part of a frond they are given off almost at a right angle, but towards the apex of the pinnate leaf they are inclined at a much smaller angle; linear in form, tapered slightly at the swollen base which was probably separated by an abciss-layer from the rachis as in *Encephalartos* and certain other recent genera of Cycads; apex acuminate and asymmetrical, the upper edge of the pinna almost straight or slightly falcate, in some cases bending downward towards the tip, the lower margin curved, bending somewhat suddenly upward to the apex in the distal third of the pinna. In shape the pinnæ vary from the practically straight form shown in the upper part of fig. 1 (pl. iii.) to the falcate type, resembling a sword-bayonet, represented in fig. 3 and in some of the pinnæ in fig. 1. The larger pinnæ reach a length of over 6 cm. and a breadth of 9 mm.; veins numerous and parallel, converging towards the base of the pinnæ where they are frequently forked (fig. 1*a*).

The type of frond shown in fig. 1, pl. iii., bears a very close resemblance to *Williamsonia gigas* (L. and H.)* of the Inferior Oolite of Yorkshire—a species which may well be identical with *Zamites schmiedelii* And.,† and *Zamites feneonis* Brongn.,‡ as well as with such forms as *Z. moreaui*, *Z. claravallensis*, and others figured by Saporta.§ Other similar species are *Zamites bohemicus* Vel.,‖ from the Lower Cretaceous rocks of Bohemia, *Zamites iburgensis* Hos. and von d. Marck.¶ Additional records might be

* Lindley and Hutton (35), pl. clxv.; Seward (00), pl. v.–viii.
† Andræ (53), pl. ix., figs. 1–4.
‡ Saporta (75), pl. lxxxvii.–xci.; Heer (76), pl. lii., figs. 2–8.
§ Saporta (75), pl. lxxxiv.–lxxxv., xciii.
‖ Frič and Bayer (01), fig. 43, p. 92.
¶ Hosius and von d. Marck (80), pl. xliv., fig. 202.

quoted of fronds bearing a very close resemblance to Tate's species. A careful comparison of the African and British examples reveals a slight difference in the shape of the pinnæ, and this possibly trivial distinction, taken in conjunction with the fact that no reproductive shoots of the *Williamsonia* type have so far been found in the Uitenhage beds, renders it advisable to use the generic name *Zamites* in preference to *Williamsonia* and to retain Tate's specific name. It may be that we shall eventually obtain evidence of the existence of the *Williamsonia* shoots in connection with *Zamites recta*, but until further evidence is forthcoming it is better to class this species simply as a member of the Cycadophyta than as a representative of a definite family. The reasons on which the British species has been assigned to *Williamsonia* and placed in the Bennettitales are fully discussed elsewhere.*

Plate III., figs. 1, 1*a* (257c, 258c).

A portion of the specimen is shown in the figure, the whole being 14·5 cm. in length. The rachis is partially hidden by the rock and so appears less than its real size; the longest pinna is approximately 5 cm. long. The veins are clearly shown and, as illustrated in fig. 1*a*, they are frequently forked close to their entrance into the lamina—a feature found also in the segments of recent cycadean fronds.

Plate III., fig. 2 (288c).

The complete specimen, of which a part only has been drawn, is 9 cm. in length; it illustrates the narrow form and greater obliquity of the pinnæ in the apical region of a frond.

Plate III., fig. 3 (A).

The single pinna shown in the figure serves as a good example of the very small angle of attachment of segments in the apical region of the frond.

A portion of the rachis, in the form of a mould, is seen close to the base of the segment.

Rachis of Zamites recta (Tate).

Plate VI., figs. 8–12.

The nature of the specimens represented in figs. 8–11 was for a long time a puzzle, and I am still in doubt as to their significance.

* Seward (00), p. 177; (97).

At first sight the examples shown in figs. 8 and 9 suggested surface-impressions of stems bearing prominent leaf-cushions, but the fact that no specimens could be found exhibiting more than two rows of the cushions was a difficulty in the way of regarding them as fragments of stems. Moreover, the two alternating rows were found in some cases (*e.g.*, fig. 8) to be situated obliquely to one another, the cushions of one row being almost at right angles to those of the other series.

It occurred to me that the narrow oval area forming the flat top of the cushions, and well shown in figs. 8 and 9, agreed in size and form with the base of the pinnæ of *Zamites recta* (fig. 12, pl. vi.); this led me to make a further search for evidence as to a possible connection of the rows of cushions with the fronds of the cycad. The discovery of the specimen represented, rather larger than natural size, in fig. 11, confirmed this view and clearly demonstrated that these apparent stems are portions of the rachis of *Zamites recta*. The following description of the figured specimens may serve to elucidate to some extent the nature of these curious fossils.

Plate VI., fig. 8 (289c).

A piece of rachis 4 cm. long, retaining fragments of carbonaceous matter (not shown in the drawing) on its surface. There are two alternating rows of prominent cushions obliquely inclined to one another; each cushion consists of a flat surface or base exhibiting a few obliquely longitudinal wrinklings, and this bears a prominent cushion-like body sloping gradually to a flat top of oval outline bounded by a fairly prominent rim. The sloping sides of the cushions are folded into small ribs and bear the impress of numerous cell-outlines, as shown in the enlarged drawing, fig. 10.

In the lower part of fig. 8 the cushions are absent, and the flat basal area is more fully exposed; the transversely elongated depression *a* occurs in the interval between adjacent cushions. Associated with *Zamites* pinnæ, *Cycadolepis*, &c.

Plate VI., fig. 9 (328c).

A single row of cushions like those shown in fig. 8.

Plate VI., fig. 10 (*a*).

A small piece of the surface of a cushion enlarged to show the fine reticulations representing the impressions of cells.

Plate VI., fig. 11 (342c).

A curved piece of rachis slightly enlarged, the actual length being 4·5 cm. In the lower part a portion of a longitudinally striated woody axis is exposed; the stout woody character of the rachis is shown in the outline of a transverse section to the left of the figure. The two lowest pinnæ rest obliquely on the axis. Against the base of the third pinna the surface of the woody axis is covered with a thin piece of rock which represents the remains of a cushion; a larger and more distinct portion of cushion is seen at *c*, and at *d* the outline of a partially preserved cushion is more distinctly seen. The position of the pinna to the left of the axis at *d* shows that the pinnæ abutted on to the side of the cushions. A more clearly defined cushion is seen at *c*, but at *b* the surface-features are still better preserved. From the upper end of the specimen the cushions are absent, but the transversely elongated depression is seen at *a*.

Plate VI., fig. 12 (286c).

Flattened rachis showing on one side the attachment of a row of pinnæ and on the other the oblique oval scars to which the pinnæ were articulated.

Other Specimens: 255c, portions of two fronds approximately parallel to one another, with fragments of others A piece of a rachis or petiole, 7 mm. broad, occurs on this slab of rock which no doubt belongs to *Zamites recta*. The longest piece of frond is 18 cm. long, and shows that the whole leaf was probably at least 40–50 cm. in length; 259c, 260c, 264c, a piece of a frond about 30 cm. long, with other fragments. The small amount of difference in the position and size of the pinnæ at the two ends points to a frond of considerable length. On the under surface of the rock there is a cast of a stem with surface features similar to *Benstedtia*. 302c, 303c, 345c, 352c. 279c, similar to some examples of *Zamites buchianus* (Ett.),* but differing from that species in the form of the base of the pinnæ. Segments of *Araucarites* scales occur on the reverse side. 323c, with the impression of a stem (?) giving off several narrow roots. 334c, with *Araucarites* scales, 346c, 372c.

* Seward (95), pl. iii., iv., viii.

Zamites morrisii (Tate).

Plate V., fig. 4.

1867. *Palæozamia* (*Podozamites*) *morrisii* Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 145, pl. v., fig. 4.

Frond pinnate; rachis broad and woody, bearing two rows of pinnæ. The pinnæ are attached either at right angles or at a very wide angle to the rachis; in shape like the head of a spear, rounded at the base and tapering to an acuminate apex. Veins numerous and parallel.

A portion of Tate's type-specimen from Geelhoutboom (Museum of Geological Society No. 11,108) of this species is figured on pl. v., fig. 4.

This solitary specimen may, as Tate believed, represent a well-marked type, distinct from *Zamites recta*, but it is by no means impossible that it may be a fragment from the basal portion of a frond of that species. It may be compared with *Otozamites acuminatus* (L. and H.)* from the Yorkshire Inferior Oolite, with which it agrees in the position and form of the segments, but the resemblance is hardly close enough to be regarded as a mark of identity. Some of the specimens from the Potomac formation of America, figured by Fontaine as *Nageiopsis ovata*† are very similar to *Zamites morrisii*. In the true *Nageiopsis* the leaves are arranged spirally as in the recent conifers *Agathis* and *Podocarpus*, whereas in *Zamites* the segments are given off from the rachis in two rows.

Plate V., fig. 4.

A portion of the type-specimen is shown in the figure. The stout woody axis bears two lateral rows of short acuminate pinnæ, which in venation and apparently also in their manner of attachment to the rachis agree with *Zamites recta*.

Zamites africana (Tate).

[Possibly identical with *Zamites rubidgei* (Tate)].

Plate V., fig. 5.

1867. *Palæozamia* (vel *Pterophyllum*) *africana*, Tate, Quart. Journ. Geol. Soc., vol. xxiii. p. 145, pl. v., fig. 5.

The type-specimen of Tate (No. 11,110, Geological Society's

* Seward (00), pl. ii., fig. 1, pl. vi., fig. 1. † Fontaine (89), pl. lxxvii., lxxx.

Museum), is represented in pl. v., fig. 5; the original figure shows only a single pinna.

If the specimen had not been named by Tate, I should have probably not ventured to record it under a specific name. The imperfect linear pinnæ shown in fig. 5 are, no doubt, segments of a pinnate cycadean frond similar to *Zamites buchianus* (Ett.); it is by no means unlikely that the specimen named by Tate *Palæozamia rubidgei*, may represent the apical portion of a frond of which the fragments referred by him to *Palæozamia africana*, are the longer and more spreading segments of the lower or median region.

Plate V., fig. 5.

(Museum of the London Geological Society, No. 11,110.)

An imperfect specimen from the Sunday River, Geelhoutboom, showing portions of five parallel pinnæ, the longest of which reaches a length of 13·5 cm., with a breadth at the lower end of 1 cm., tapering gradually towards a narrow acuminate tip. The veins are represented as prominent ribs. The dotted outline in the figure indicates that a portion of the rock is not represented.

ZAMITES RUBIDGEI (Tate).

[Possibly identical with *Zamites africana* (Tate).]

Plate V., fig. 3.

1867. *Palæozamia rubidgei*, Tate, Quart. Journ. Geol. Soc., vol. xxiii., p. 145, pl. v., figs. 3*a*, 3*b*.

Frond pinnate, bearing two lateral rows of linear pinnæ. The pinnæ are confluent and decurrent on the rachis; veins numerous and parallel.

The type-specimen of Tate (Museum of the Geological Society, No. 11,109) is refigured on pl. v., fig. 3. I have not met with any examples of this type in the collection recently received from Cape Colony. It is possible that the discovery of more perfect material may render it advisable to substitute for *Zamites* some other generic name, but for the present I prefer to make use of that designation. The fragment may be compared with such a fossil found as *Zamites buchianus* (Ett.) of Wealden age,* as described from England, Germany, Japan, and elsewhere. The veins are parallel and, so far

* Seward (95), p. 79, pl. iii., iv., viii. A. Nathorst (90), pl. ii., iii., v.

as one can see, not connected by transverse or oblique anastomoses, but in other respects Tate's species agrees closely with *Ctenis falcata* L. and H. A very similar form of leaf is represented also by a specimen in the York Museum from the Inferior Oolite beds of East Yorkshire; but until we obtain more material Tate's species cannot be more fully defined or compared with other types. The specimen probably represents a portion from the apical region of a frond of similar form to the Wealden species *Zamites buchianus* (Ett.).

Genus NILSSONIA.

Nilssonia tatei sp. nov.

Plate IV., figs. 1, 2.

The specimens (291c, 293c), on which this species is founded, are almost too fragmentary to name, but the portions of fronds represented in figs. 1 and 2, with an imperfectly preserved larger specimen (293c), enable us to obtain some idea as to the general form of the complete leaf.

Frond consisting of a prominent woody axis bearing a lamina dissected into long band-like segments of unequal breadth, separated from one another by fairly broad sinuses reaching to the rachis. The lamina appears to have extended on to the upper face of the rachis, and was probably continued over it as in the typical *Nilssonia* fronds; the segments are traversed by numerous parallel veins which were single or forked close to their origin from the axis. The species with which the Uitenhage fragments exhibit the closest similarity have been described under the generic name *Pterophyllum*, but there appears to be enough evidence in the present case to assign the specimens to *Nilssonia*.

Among Indian forms, the following may be compared with *Nilssonia tatei*:—

Pterophyllum princeps O. and M.,* *P. rajmahalense* Morr.,† *P. carterianum* Old.,‡ *P. morrisianum* Old.,§ *P. falconerianum* Morr.,‖ and *P. medlicotianum* O. and M.¶ Other similar species are *Pterophyllum helmerseniauum* Heer,** a Jurassic Siberian type, *Pterophyllum æquale* Brongn.,†† as figured by Nathorst from the

* Oldham and Morris (63), pl. x.
‡ *Ibid.*, pl. xv., fig. 4.
‖ *Ibid.*, fig. 2.
** Heer (77), pl. xxv., fig. 5.
† *Ibid.*, pl. xiii., fig. 4.
§ *Ibid.*, fig. 1.
¶ *Ibid.*, fig. 3.
†† Nathorst (79), pl. xv.

Rhætic of Scania, another European Rhætic species, *Nilssonia acuminata* Goepp.,* and a Queensland fossil described by Shirley as *Pterophyllum quadriflorum.*†

Plate IV., figs. 1, 2 (291c).

These fragments illustrate the characters referred to above. The preservation is far from perfect, and it is possible that the reference to *Nilssonia* is incorrect. In the lower right-hand segment of fig. 1 the lamina extends up to the middle of the rachis, and in this respect agrees with species of *Nilssonia.*

Other Specimens: 293c, part of a frond 8 cm. long. The lamina is much torn and broken, but there appear to be entire segments broader than those represented in pl. iv., figs. 1, 2. The veins are clearly preserved; in the lower part of the specimen they spring from the rachis approximately at right angles, in the apical region being given off at a much smaller angle; they are approximately 1 mm. apart, rather less numerous than in the specimens represented in figs. 1, 2, pl. iv. The lamina, at least in the apical region, appears to be practically continuous over the axis of the leaf.

Also specimens of *Araucarites* scales.

Genus CYCADOLEPIS Saporta.

We owe this generic designation, to Saporta,‡ who made use of it for fossils which he regarded as bud-scales of cycadean fronds. In Part II. of the British Museum Catalogue of the Wealden Flora § I extended this term to include "Scale-like leaf structures of cycadean plants, varying considerably in form and including detached petiolar bases, bud-scales, &c., also isolated carpellary or antheriferous scales which exhibit no trace of ovules or pollen-sacs."

We might add to this designation, scale-like structures which may have served as a protective covering to young and unexpanded vegetative leaves or fertile shoots.

* Schenk (67), pl. xxxiii.
† Shirley (98), p. 16, pl. xix. and xxiv.
‡ Saporta (75), p. 200.
§ Seward (95), p. 96.

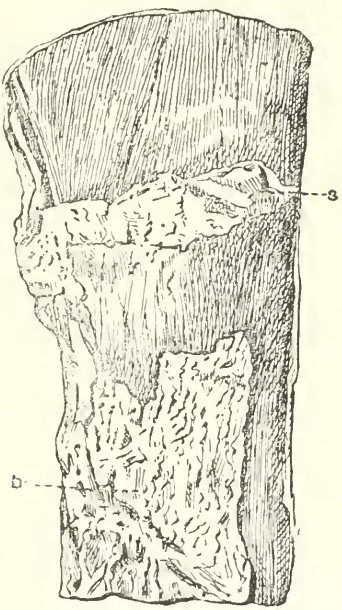
Cycadolepis jenkinsiana (Tate).

Plate IV., figs. 3–6.

Text-figure 2.

1867. *Cyclopteris jenkinsiana*, Tate, Quart. Journ. Geol. Soc., vol. xxiii., pl. vi., fig. 4, p. 146.

Scale-leaves more or less orbicular in shape, reaching a length of rather more than 12 cm. and a breadth of almost equal dimensions; attached to the supporting organ by a broad



Text-figure 2. (Nat. size.)
Cycadolepis jenkinsiana (Tate).

base. The lamina is traversed by a well-defined midrib consisting of several parallel veins (fig. 5), but most of the veins spread from the base towards the sides and distal edge, forking repeatedly as in the *Cyclopteris* type of venation; between and above the veins occur numerous fine anastomosing and irregularly disposed lines (figs. 4, 5) which present the appearance of the remains of a felt of hairs which originally covered the whole lamina. The scale-leaf

often occurs folded on itself along the median line as if functioning as a protective or stipular organ.

The specimen figured by Tate as *Cyclopteris jenkinsiana* is undoubtedly identical with that represented in pl. iv., figs. 3–6. An examination of his type-specimen in the Museum of the Geological Society reveals certain imperfections in the published drawing, although on the whole the figure is by no means inaccurate; the outline of the fossil is more ill-defined and irregular than the drawing suggests, and under a low magnifying power the surface resolves itself into an irregular network of fine lines, as shown in fig. 5, pl. iv. (specimen 319c). Veins, like those seen in fig. 6, may be detected here and there in Tate's specimen, but for the most part they are too obscure to recognise; the texture of the leaf and the irregular fine lines over the surface present an appearance as of some woolly covering over the whole lamina, as shown also in fig. 4, pl. iv.

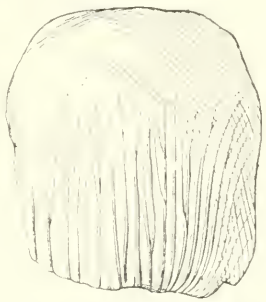
The specimen shown in text-figure 2 presents the appearance of a flattened stem, but the surface features, as seen on the side figured, are clearly those of *Cycadolepis;* along one edge there are distinct traces of veins following a vertical course, and from them numerous veins spread in an obliquely ascending direction towards the right-hand upper edge of the cast. A short distance below the upper end of the specimen a transversely elongated scar, *s*, marks the position of an appendage, which was possibly another *Cycadolepis* sheathing scale. Part of the surface is covered by a thin mineral layer, *b*, which exhibits no definite texture. The whole specimen is 8 cm. long by 4·5 cm. broad, and has a compressed elliptical form in section: it represents, I believe, the cast of a branch bearing several sheathing scale-leaves, and may well belong to *Benstedtia*. While admitting the absence of decisive proof, I am inclined to regard *Cycadolepis* as a bract-like organ borne on the branches of *Benstedtia* and functioning as a protection to the young and unexpanded leaves.

The specimens represented in pl. iv., figs. 3–6, present a fairly close resemblance to some Wealden fossils described in 1895 as examples of Saporta's genus *Cycadolepis*, and included in a subsection *Eury-Cycadolepis*, which was defined as follows: "Broadly oval or orbicular scales, with the broadest portion frequently nearer the distal than the proximal end; thick and fibrous structures."*

Two examples of these scales are shown in text-figures 3 and 4.

* Seward (95), p. 96.

I regarded the English Wealden specimens as stout and leathery scales which were originally attached to a cycadean stem, comparing them with the large persistent petiole bases of the recent *Macrozamia douglasi* and other cycads. This comparison still seems to me justified by the close resemblance between the fossils and the scales of recent cycadean stems as well as with such fossil scale-leaves or leaf-bases as those in Carruthers' genus *Fittonia*.* The English specimens usually show no trace of venation, but in the small example shown in fig. 3 there are several clearly marked veins springing from the basal end. In the larger specimen (fig. 4) the surface shows in places numerous irregular wrinklings similar to those in *Cycadolepis jenkinsiana*. The curved ridge stretching across the scale close to the base of the specimen

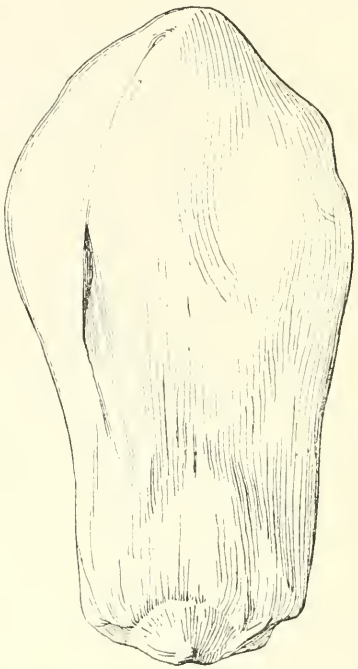


Text-figure 3. (Nat. size.) (British Museum Collection, No. V. 2131a.) *Cycadolepis* from the Wealden of England.

drawn in fig. 4 shows the area of attachment and agrees closely with a similar feature in the Uitenhage examples. In the African specimens the lamina is often folded along the median line, a character not noticed in the English forms, and the latter differ in the apparently greater robustness and less leaf-like nature. On the whole I am disposed to consider the Uitenhage fossils as detached leaf-like bodies borne, possibly, on a cycadean stem and serving as protective structures to leaves during the earlier stages of growth. They may be compared with the stipules of the Marattiaceæ among ferns, and with the much smaller scale-leaves of modern cycads. It is true that existing cycadean plants do not possess structures that function as sheathing bracts and bear a close resemblance to *Cycadolepis jenkinsiana;* a nearer analogy

* Carruthers (70), p. 690.

with the fossil scale-leaves is presented by the sheathing stipules of such recent ferns as *Marattia*, *Angiopteris*, *Todea;* among Palæozoic ferns we have the so-called *Aphlebiæ*, which, in some cases at least, acted as protective scales to unexpanded fronds. It may be that the fossils referred to *Cycadolepis* should rather be described as fern leaves, but I incline to the view that they are cycadean for the following reasons: They correspond fairly closely



Text-figure 4. ($\frac{1}{3}$ nat. size.) (British Museum Collection, No. V. 2799.)
Cycadolepis from the Wealden of England.

with the English specimens which I have little or no hesitation in referring to cycads; they occur in almost constant association with the fronds of *Zamites recta* in the Uitenhage beds. We know that Mesozoic cycads possessed more fern-like characters than are found among their modern representatives, and it would not be surprising to find that some types produced scale-leaves comparable with the *Aphlebiæ* of extinct species of ferns and the stipular appendages of certain existing genera.

Plate IV., fig. 3 (315c, 316c).

This specimen has a length of 7·5 cm.; it is not quite complete at the distal margin (lower end of drawing); its greatest breadth is 7 cm., but the edges are slightly torn and imperfect. At the upper end, as seen in the figure (the base of the specimen), there is a straight edge to the lamina, which no doubt marks the original place of attachment. The lamina is traversed by numerous spreading veins, as in a true *Cyclopteris*, but the median portion is occupied by more numerous parallel veins which form a fairly distinct and broad midrib. Over part of the surface the veins are obscured by the presence of flexuous and irregularly anastomosing fine lines. The resemblance to Tate's type-specimen is very close, as regards shape, the presence of a midrib, and the surface texture.

Fragments of *Zamites* fronds and rachis with Araucarian scales and seeds occur on the back of this slab.

Plate IV., fig. 4 (280c).

A scale similar to that shown in fig. 3, but rather less and with a more complete base (upper end of drawing). The well-marked slightly curved line at the termination of the midrib may be regarded as the broad attachment-area by which the scale was articulated to its supporting organ. The outline is torn and very indistinctly defined; the surface features agree exactly with those in Tate's type-specimen.

Plate IV., fig. 6 (311c).

A scale 12 cm. long, torn across close to the base. The lower margin is clearly defined, but the distal end and upper edge are torn and incomplete; the whole is traversed by veins, which are in places hidden by the presence of the fine hair-like markings shown between the ribs in fig. 5; the veins run parallel to the upper edge, which is approximately in the position of the midrib, on which the whole lamina was evidently folded as if clasping and protecting some immature organ. The drawing, therefore, probably represents a large scale-leaf folded along its axis.

Plate V., fig. 5 (319c).

A portion of a scale-leaf enlarged three times to show the veins as prominent ribs and the delicate carbonaceous lines forming an irregular network in the intercostal areas.

Other Specimens: A, a specimen 7 cm. long by 6·5 broad, convex in section, and evidently a portion of a broad scale-leaf folded on itself; veins clearly defined. 265c, a good example of the basal portion of *Cycadolepis* (*Zamites* on the reverse side). 305c, 313c, 314c, a specimen about 10 cm. long showing the veins over part of the surface. 313c, with *Zamites* pinnæ. 320c, a good impression of part of a *Cycadolepis* showing the line of attachment at the base and the spreading veins. The broad base of the midrib is clearly preserved. A fragment of *Onychiopsis* on the reverse side. 321c, with *Zamites* and ? *Benstedtia*. 324c, 326c (*cf.* 305c), 335c, and *Zamites*, 336c, 371c.

Genus BENSTEDTIA.

In 1862 Mr. Mackie * described and figured a fossil stem from Lower Greensand rocks in Kent, which König named *Dracæna benstedtii*. This name was adopted by Morris † and by Mantell. In 1868 Carruthers ‡ expressed the opinion that the fossils discovered by Mr. Bensted presented a closer resemblance to *Pandanus* than to *Dracæna*, but Gardner § afterwards alluded to the specimens as possibly cycadean. An examination of Mackie's original specimen in the British Museum, and of other examples from Lower Greensand and Wealden rocks, led me to adopt the view that König's *Dracæna* is in all probability the stem of a cycad. In most recent cycads the surface of the stem is encased in an armour of persistent leaf-bases, but in *Zamia* (*e.g.*, *Z. skinneri* Warsz., *Z. loddigesii* Miq., &c.) and in *Cycas siamensis* Miq. the leaf-bases are replaced by a corky investment bearing numerous oval protuberances and irregular transverse wrinklings. This close resemblance between the fossil and recent stems caused me to institute a new generic name, *Benstedtia*,‖ to be applied to such fossil stems as agree in surface features with cycadean trunks of the *Zamia* type. *Benstedtia* is defined as follows:—

"Stems having the surface marked by irregular and interrupted grooves and broader ridges running transversely, with occasional small elliptical protuberances irregularly disposed on the surface of the stem. No distinct leaf-scars; branch-scars may be present, and in addition to smaller lateral branches, a bifurcation of the stem

* Mackie (62), pl. xxii.
† Morris (54), p. 8.
‡ Carruthers (68), p. 154 (footnote).
§ Gardner (86), p. 201.
‖ Seward (96).

may be indicated by the converging upwards of the transverse lines on the surface of the stem."

Since the publication of my paper in which the genus *Benstedtia* was suggested, Professor Fliche, of Nancy, has described some casts of stems from the Lower Cretaceous of France under the name *Coniferocaulon*.* The fossils are, I believe, identical with those referred to *Benstedtia*. Professor Fliche draws attention to the resemblance as regards surface features to stems of *Araucaria* of the section *Colymbæa*, but does not suggest a comparison with *Zamia*. Without anatomical evidence it is impossible to say whether the fossil stems are cycadean or coniferous, but the resemblance to *Zamia* is at least as striking as their similarity to *Araucaria*, and in case of doubt a non-committed term such as *Benstedtia* is preferable.

Benstedtia sp.

(Cf. *Coniferocaulon colymbeæforme* Fliche.)

Plate V., fig. 2.

Text-figure 5.

The Uitenhage specimens referred to this genus are very similar to those previously figured from Maidstone † and from the Sussex coast.‡ They include partially flattened cylindrical casts, with occasional branch-scars, and portions of much broader stems like that represented in fig. 2, pl. v.

The collection of Uitenhage plants in the Museum of the Geological Society contains a few imperfect specimens like that shown in fig. 2, pl. v., which Tate identified as probably cycadean.§ I agree with his determination, and, while admitting the absence of proof, am disposed to consider the specimens as casts of some cycadean plant. The frequent association of these stems with the fronds of *Zamites recta* is a point in favour of the supposition that they represent portions of the same plant; possibly the large *Cycadolepis* scale-leaves may also have been borne on *Benstedtia* stems. This is, however, merely a suggestion, in support of which I am unable to furnish anything of the nature of proof.

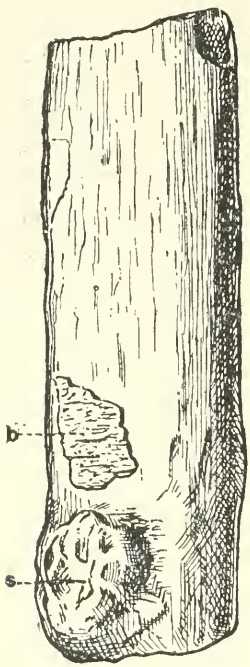
The stem casts figured by Fliche ‖ from Lower Cretaceous rocks of France (La Haute-Marne) as *Coniferocaulon colymbeæforme*

* Fliche (00). † Seward (96), pl. xiv. ‡ Seward (95), pl. xii.
§ Tate (67), p. 147. ‖ Fliche (00), fig. 1–3.

appear to be identical with those from South Africa; the surface features are the same, and in both cases branch-scars occur. It is possible, as Fliche suggests, that the stems are those of an Araucarian plant, but whether their determination as coniferous or cycadean is more likely to be correct must be left undecided.

Plate V., fig. 2 (292c).

A portion of a large piece of bark, 10 cm. by 9 cm. The axis traversing the surface obliquely—as shown in the drawing—is prob-



Text-figure 5.
Benstedtia sp. 387c. (Nat. size.)

ably a foreign body, and may be the rachis of *Zamites recta*. The surface characters as shown in fig. 2 appear to be exactly of the type described in the English specimens of *Benstedtia*.

Text-fig. 5. A flattened cast, 8·5 cm. long and 2·7 cm. broad, showing one branch-scar, *s*. The cast is for the most part covered with a layer of bark exhibiting the characteristic tuberculated and

wrinkled surface of *Benstedtia*. Very similar to Fliche's specimen represented in his fig. 2. On the face of the cast shown in the drawing the bark is represented by a very small piece—*b*, exhibiting the *Benstedtia* texture.

Other Specimens: 297c, an almost flat impression, 12 cm. long, with some carbonaceous matter on the surface, bearing numerous tubercles, reminding one of the transversely elongated lenticels on a piece of birch bark. 338c, with fragments of *Cladophlebis browniana* and a coniferous twig. 364c, with *Zamites*, 379c the cast of a stem 32 cm. long, showing a single branch-scar; one side is covered with a layer of bark similar to that shown in pl. v., fig. 2, resting on the woody substance of the stem. 380c, a narrow branching cast, probably referable to *Benstedtia;* 381c, 382c, 383c, 384c, 386c.

CYCADOPHYTA?

Genus CARPOLITHES Sternberg.

Carpolithes sp.

The collection includes a single seed (388c) of oval nut-like form, 1·3 cm. long by 9 mm. in breadth. In shape it represents that of a recent cycad rather than the seed of a conifer, and may be included under Gymnospermæ as a doubtful representative of the Cycadophyta.

Group CONIFERALES.

Family ARAUCARIEÆ.

Genus ARAUCARITES Presl.

Araucarites rogersi * sp. nov.

Plate VI., figs. 4–7.

Cone-scales broad, reaching a breadth of 3 cm.; distal margin straight, prolonged into a short median appendage (fig. 4), and

* After my friend, Mr. A. W. Rogers, of the Geological Commission of Cape Colony.

bending down into a thin lateral wing, as in the scales of *Araucaria cookii* and other recent members of the *Eutacta* division of *Araucaria;* surface of the scales characterised by the occurrence of forked ribs (vascular bundles), which follow a more or less vertical course; each scale bears a single obovate seed, terminating distally in a bluntly rounded base. No trace of a "ligule."

The collection includes several examples of cone-scales like those represented on pl. vi., figs. 4–7, which agree so closely with the cone-scales of *Araucaria cookii* and other recent species of *Araucaria* that I have no hesitation in referring them to the genus *Araucarites*. They are practically identical with the recent type of ovuliferous seeds characteristic of the *Eutacta* section of *Araucaria*. There is one specimen in the Museum of the Geological Society (11,117) collected by Atherstone in 1858, which is no doubt the example referred to by Tate as "the under surface of the base of a cone," * and doubtfully determined as cycadean. This specimen represents several broad scales adhering together in their original position. Among fossil forms there are several Mesozoic species which present a close resemblance to *Araucarites rogersi*, but the agreement is hardly such as to justify the inclusion of the African cone-scales in any previously recorded species. *Araucarites macropteris* † and *A. cutchensis*,‡ described by Feistmantel from the Rajmahal and Jabalpur series of India, represent closely allied types. *Araucarites wyomingensis* Ward,§ from the Neocomian of Dakota, affords evidence of the occurrence of a similar species of the genus in North America. Among English species *Araucarites brodiei*,‖ *A. phillipsii*,¶ *A. sphærocarpus*,** described by Carruthers from Jurassic strata, afford other examples of broad Araucarian cone-scales; and a specimen figured by Frič and Bayer from Lower Cretaceous rocks of Bohemia as "cf. *Araucaria bohemica* Vel.," †† may also be mentioned as evidence of the existence of this type of *Araucarites* in Europe.

In the absence of more perfect material it is probably better to include the smaller scale represented in fig. 5, pl. vi., with the larger form under one specific name.

* Tate (67), p. 147.
† Feistmantel (77[2]), pl. viii., figs. 9–12; (79), pl. xiv., xvi.
‡ Feistmantel (79), pl. xiv., xvi.
§ Ward (99), pl. clxiii., figs. 1–6, 8, 9.
‖ Carruthers (69[2]), pl. ii., figs. 1–6.
¶ *Ibid.*, pl. ii., fig. 7–9; Seward (00), pl. x., fig. 4.
** Carruthers (66) (71). †† Frič and Bayer (01), fig. 50.

Plate VI., fig. 4 (298c).

This scale—3 cm. long—shows clearly the impressions of the vascular bundles over the area originally occupied by the seed. The thin lateral margins are partially preserved, but in the perfect scale the breadth was no doubt slightly greater. In the middle of the distal edge the scale shows part of a projection similar to the longer outgrowth seen in *Araucaria cookii*, the scales and seeds of which agree closely with those of *Araucarites rogersi*.

Plate VI., fig. 5 (298c).

A much smaller and less perfect scale, similar to *Araucarites cutchensis*, as figured by Feistmantel from the Upper Gondwanas of the Madras Coast,* and to some scales of *Araucarites phillipsi* Carr.†

Plate VI., fig. 6 (295c).

Two imperfectly preserved overlapping scales, each showing the outline of a seed. The two scales are so closely pressed together that it is almost impossible to trace the boundary between them.

Plate VI., fig. 7 (300c).

This specimen shows more clearly the broad membranous wing. Part of the projection from the distal margin is preserved, a depression in the middle line of the scale indicating the position of the seed.

Other Specimens: 301c, 304c (with fragments of *Zamites*), 306c, 307c, 308c (with *Zamites*, &c.), 319c (with good impression, on the reverse side, of *Cycadolepis*), 322c, 330c, 331c, 337c.

CONIFERALES OF DOUBTFUL POSITION.

Genus TAXITES Brongniart.

This artificial genus is convenient for the inclusion of fragments of vegetative twigs, presumably of conifers, resembling those of *Taxus*, *Sequoia sempervirens*, *Torreya*, and some other types of recent Coniferæ, in having narrow linear leaves traversed by a single midrib and disposed in a two-ranked arrangement. Many of the

* Feistmantel (79), pl. xiv.

† *Cf.* Seward (60), pl. x., fig. 4.

fossil fragments referred by authors to the genus *Palissya* and to *Sequoia* have the vegetative characters of the comprehensive genus *Taxites*.

Taxites sp.

Plate VI., fig. 15.

The fragment represented in fig. 15 is too small and incomplete to refer to a distinct species; twigs of this type are exceedingly common in Mesozoic Floras, and, in the absence of reproductive organs, cannot be placed with any degree of certainty in a particular family. Similar coniferous shoots are recorded by Feistmantel from India as *Taxites planus* * and *Palissya* (*?*) *jabalpurensis*; † the British type, *Taxites zamioides*,‡ of Inferior Oolite age, is another of the numerous examples that may be compared with the Uitenhage specimen.

Plate VI., fig. 15 (Y).

A fragment showing numerous linear leaves attached by a base which is decurrent on the axis of the shoot. The leaves appear to have a single median vein.

Associated with fragments of *Cladophlebis denticulata* forma *atherstonei*.

The only other specimen in the collection is 176d.

Genus BRACHYPHYLLUM Brongniart.

Brachyphyllum sp.

Plate VI., figs. 13, 18.

The scraps of coniferous twigs preserved in the Uitenhage plant-beds are too fragmentary and imperfect to refer with confidence to any species.§ Tate mentions the occurrence of portions of a coniferous stem, which are no doubt identical with that represented in fig. 13, "closely allied to *Athrotaxites indicus* Old." ‖ This type of stem is exceedingly abundant in Wealden and Jurassic rocks; it is recorded by many authors under the genus *Brachyphyllum*, while others adopt the names *Echinostrobus* or *Athrotaxites*. Feistmantel's

* Feistmantel (79), pl. xiii.–xv.
† Feistmantel (77³), pl. ix., x.
‡ Seward (00), pl. x., fig. 5.
§ Tate (67), p. 147.
‖ Oldham and Morris (63), pl. xxxii., fig. 8.

Echinostrobus rajmahalensis may be referred to as one of the many similar types of Coniferous shoots, also the widely spread species *Brachyphyllum mamillare* Brongn., but without more material specific identification is hopeless.

Plate VI., fig. 13 (299c).

The figure represents a portion of the specimen; the branch was clothed with crowded and spirally disposed leaves, which were probably of the thick and fleshy *Brachyphyllum* type.

Associated with *Araucarites* scales and with *Zamites recta*.

Plate VI., fig. 18 (348c).

A small piece of a branched twig showing a well-defined reticulum marking the spaces between the crowded leaves or leaf-cushions. Each mesh of the reticulum is occupied by a flat area divided into an upper and a lower region, and showing in the upper third of the median line a patch of carbonaceous material. The whole (fig. 18) presents a superficial resemblance to the leaf-cushion and leaf-scar of a *Lepidodendron*.

The portion figured has a length of 3·5 mm.

In addition to fragments like that represented in fig. 13, pl. vi., a few smaller examples of coniferous twigs occur (354c, 355c) of the type shown in fig. 2. These smaller pieces show the apices of the appressed and thick leaves projecting slightly from the axis of the branch. A comparison may be made between these more slender shoots and the European Wealden species *Sphenolepidium kurrianum* (Schenk), but it would be rash to suggest specific identity.

Genus CONITES Sternberg.

Conites sp. *a*.

Plate VI., figs. 2, 2*a*.

The two small and somewhat obscure cones shown in fig. 2 (310c) appear to be attached to a slender branched axis, but they are not in organic connection with the adjacent twig. It is impossible to determine the nature of these cones, whether male or immature female; the small dimensions suggest a comparison with the male flowers of recent Coniferæ, but, on the other hand, the comparatively

broad character of the cone is a point in favour of a comparison with such small, presumably female, cones as those of the Wealden *Sphenolepidium sternbergianum* (Schenk),* *Ceratostrobus echinatus* Vel.,† of Lower Cretaceous age, and some small cones described by Fontaine from the Potomac formation ‡ as "aments of conifers." The cone-scales as shown in fig. 2*a* are imperfectly preserved, but there are indications of a central keel or projection on their expanded distal ends.

Conites sp. *β*.

Plate VI., figs. 1, 1*a*, 3.

These cones may be specifically identical with the slightly broader form represented in fig. 2, but their relatively longer and narrow form suggests that they are male flowers.

Plate VI., figs. 1, 1*a* (253c).

The cone represented natural size in fig. 1 shows numerous spirally disposed, distally expanded scales with traces of a small central umbo (fig. 1*a*), which may well be sporophylls bearing pollen-sacs.

Plate VI., fig. 3 (298c).

A cone seen in longitudinal section, showing the sporophylls attached at right angles to the axis of the flower.

Other Specimens: 250c, 251c, 252c.

CONIFEROUS WOOD.

In addition to the stem casts referred to the genus *Benstedtia*, the collection includes a few specimens of what is probably true coniferous wood; but without petrified examples it is impossible to attempt an accurate determination.

Specimen x. This specimen represents a sandstone cast, 19 cm. long, and at least 8 cm. in diameter. The contour of the surface is the chief point of interest; the wood of the stem or root was con-

* Schenk (71), pl. xxxviii., fig. 13.

† Velenovsky (85), pl. xi., figs. 13, 15.

‡ Fontaine (89), pl. cxxxvi., fig. 2.

siderably swollen at intervals; the cast presents the appearance of a transversely corrugated axis with broad, transverse swellings and intervening grooves. There are two branch-scars. The irregularity in the diameter suggests a comparison with the root wood of recent conifers. Somewhat similar casts are recorded by Goeppert * from the Quadersandstein of Silesia as *Cylindrites spongioides*.

Specimens 32c, 33c, 34c, 36c, probably represent portions of coniferous wood, but in the absence of petrified tissues an accurate determination is out of the question.

PLANT OF DOUBTFUL POSITION.

Plate VI., fig. 14.

The specimen represented in fig. 14 (332c) consists of two thick bodies, consisting of a short stalk terminating expanding into a semicircular head. In the lower part of the expanded head there is a well-defined depressed area, bounded below by a straight line and by a curved line above, which may be the scar of some appendage. The surface is irregularly pitted.

The collection includes a few other isolated bodies like the two shown in the drawing (*e.g.*, 326c).

Some detached scales figured by Frič and Bayer † from Lower Cretaceous rocks of Bohemia as *Dammara borealis* Heer bear a resemblance to fig. 13, but I must leave them as portions of a plant of uncertain position.

III.—CONCLUSION.

The following list includes all the species and genera recognised in the Uitenhage Flora; the localities from which the specimens were obtained are added after each name:—

Filicales.

Onychiopsis mantelli (Brongn.)..... Bezuidenhout River, Witte River. (Both localities on the farm Geelhoutboom, now the Roman Catholic Mission Station, Dunbrodie.)

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* Goeppert (41), pl. xlvi., xlviii., p. 115.

† Frič and Bayer (01), p. 95, fig. 47.

Cladophlebis browniana (Dunk.).	Bezuidenhout River.
Cladophlebis denticulata (Brongn.) forma *atherstonei*	Herbertsdale, Bezuidenhout River.
Sphenopteris fittoni Sew.	Bezuidenhout River.
Sphenopteris sp.	Sunday River, Dunbrodie.
Tæniopteris sp.	Herbertsdale, Bezuidenhout River.

CYCADOPHYTA.

Zamites recta (Tate).	Bezuidenhout River.
Zamites morrisii (Tate).	
Zamites africana (Tate).	
Zamites rubidgei (Tate).	
Nilssonia tatei sp. nov.	Bezuidenhout River.
Cycadolepis jenkinsiana (Tate)	Bezuidenhout River.
Benstedtia sp. (cf. *Coniferocaulon columbæforme* Fliche)	Bezuidenhout River.
Carpolithes sp.	Bezuidenhout River.

CONIFERALES.

Araucarites rogersi sp. nov.	Bezuidenhout River.
Taxites sp.	Herbertsdale.
Brachyphyllum sp.	Bezuidenhout River.
Conites sp. *α.* }	Bezuidenhout River.
Conites sp. *β.* }	
Coniferous Wood	Bezuidenhout River.
Planta incertæ sedis	Bezuidenhout River.

Onychiopsis mantelli (Brongn.). This species, although probably not absolutely confined to rocks of Wealden age, is essentially a characteristic member of floras belonging to that epoch. It has a wide geographical distribution in Europe, and occurs in North America and Japan. *Onychiopsis mantelli* must have been one of the most abundant plants in the vegetation of which fragments are preserved in the Uitenhage beds.

Cladophlebis browniana (Dunk.). As already pointed out, it is almost impossible to determine fronds of this type with accuracy, but the specimens with which the South African specimens appear to be identical is a Wealden fern of common occurrence in Europe and in the Far East. The distinction between Wealden and Inferior Oolite species is in many cases by no means well marked, and this form of frond, taken by itself, cannot be regarded as a trustworthy index of the Wealden age of a flora.

Cladophlebis denticulata (Brongn.) forma *atherstonei*. This repre-

sents another very abundant and widely distributed type of frond met with in rocks ranging in age from Rhætic to supra-Wealden. Taken by itself this almost ubiquitous form of fern does not afford conclusive testimony of age, but it is chiefly characteristic of the Upper rather than the Lower Jurassic series, and of Lower Cretaceous rocks.

Sphenopteris fittoni Sew. A less widely spread type and a safer criterion of age, indicating Wealden rather than a lower horizon.

Sphenopteris sp. Too fragmentary a specimen to serve as a safe guide.

Tæniopteris sp., cf. *T. arctica* (Heer.). Another common type, but on the whole nearer to a species of Lower Cretaceous age than to Jurassic types of *Tæniopteris*.

Zamites recta (Tate). The fronds of this species are very similar to those of *Williamsonia gigas* (L. and H.), a characteristic Jurassic plant. The separation of pinnate cycadean fronds of the form represented by *Zamites recta* into well-defined species is hardly possible; but whether Tate's species be distinct, or identical with a European type, it undoubtedly agrees more closely with Jurassic than with Wealden cycadean fronds.

Zamites morrisii (Tate). The type-specimen of Tate is the only example so far obtained; it may be a distinct species, but it is by no means unlikely that it may prove to be identical with *Z. recta*. It throws no further light on the question of age.

Zamites africana (Tate). Too fragmentary to be used as evidence of age, but resembling a Wealden species, *Zamites buchianus* (Ett.), perhaps more closely than a Jurassic type.

Zamites rubidgei (Tate). Fronds are known of both Jurassic and Wealden age which bear a close resemblance to the single specimen on which this species was founded by Tate.

Nilssonia tatei sp. nov. On the whole species of Jurassic age from Indian and European localities exhibit the closest resemblance to this form.

Cycadolepis jenkinsiana (Tate), and *Benstedtia* sp.	The scale-leaves and stems from English and Wealden beds referred to in the account of these Uitenhage fossils show a very close resemblance to the African specimens.

Araucarites rogersi sp. nov. The genus *Araucarites* was widely distributed as a member of Jurassic floras, but its occurrence also in Wealden beds renders it of uncertain value as an index of age. Such forms of Araucarian cone-scales as resemble *Araucarites rogersi* most closely are from Jurassic horizons.

It seems clear that the Uitenhage plants include types in part characteristic of Wealden and in part indicative of Jurassic floras. On the whole there is a balance of evidence in favour of a Wealden horizon. The comparative paucity of species and the fact that several forms are represented by small fragments render conclusions as to age somewhat difficult; but I have little hesitation in stating that the flora exhibits more well-defined points of contact with plants of Wealden age than with older floras. The impression given by the occurrence of Wealden species with others more nearly allied to Jurassic types is that this flora from Cape Colony, represented by a small number of species, marks a phase of Mesozoic vegetation on the boundary of the Jurassic and Wealden periods. Between Wealden floras, especially such as are known from the lower beds of the formation, and Oolitic floras, there exist but minor differences. It was during the period immediately succeeding that represented by the English Wealden strata that the plant-world experienced a striking change. Before this change took place there appears to have been a long period during which but little alteration occurred in the composition of the Mesozoic vegetation.

II.—*STORMBERG FLORA.*

Plates VII.–IX., XI., figs. 2, 3.

Text-figures 6 and 7.

I.—INTRODUCTION.

The plants included in this section were obtained from the following localities: Maclear and neighbourhood, Tina River, Kenigha River, Matatiele, Edward's Hope, Cyphergat, Molteno, and Stormberg. The most important account of the flora of this uppermost division of the Karoo formation is that by Feistmantel,* who refers to the Stormberg beds as probably of Lias-Rhætic age. The floras of other regions—Scania and Franconia in Europe, Australia, and the Argentine Republic in the Southern hemisphere—with which the African plants are most nearly allied are usually described as Rhætic in age, and there is little doubt that the Stormberg flora should be regarded as a member of the Rhætic vegetation. Feistmantel records the following species from Indwe River, Stormberg, Cyphergat, and Molteno :—

Feistmantel (1889).	Seward (1903).
Equisetaceous stem fragment.	Equisetaceous stem fragment.
Sphenopteris elongata Carr.	*Stenopteris elongata* (Carr.).
Thinnfeldia odontopteroides (Morr.). *Thinnfeldia trilobita* (?) Johnst.	*Thinnfeldia odontopteroides* (Morr.).
Tæniopteris carruthersi T.-Woods. *Tæniopteris daintreei* McCoy.	*Tæniopteris carruthersi* T.-Woods.
Anthrophyopsis (?) sp.	*Chiropteris elongata* (?) (Carr.).
Alethopteris sp. (cf. *Asplenium nebbense* Heer).	*Cladophlebis* sp.
Podozamites (*Zeugophyllites*) *elongatus* (Morr.). *Podozamites* (*Zeugophyllites*) sp.	*Phœnicopsis elongata* (Morr.).
Baiera schencki Feist.	*Baiera schencki* Feist.

* Feistmantel (89).

II.—DESCRIPTION OF SPECIMENS.

Group **EQUISETALES.**

Genus SCHIZONEURA Schimper and Mougeot.

Schizoneura krasseri sp. nov.

[Probably identical with *Schizoneura carrerei* Zeiller.]*

Plate IX., figs. 5, 6.

1900. ? *Schizoneura* sp. Krasser, Denksch. K. Akad. Wiss. Wien, Bd. LXX., p. 146, pl. iii., figs. 1–3*a*.

Stems broad; internodes long, reaching a length of over 20 cm., the internodal ridges crowded, pursuing either a straight course across the node or occasionally alternating. Nodes shown as slight depressions with indications of small leaf-trace protuberances.

Although it is impossible to give a satisfactory diagnosis of the Stormberg Equisetaceous stems, I have ventured, for the sake of convenience, to append a specific name, and in view of the probable identity of the African plant with that described by my friend Dr. Fridolin Krasser from China, I have designated the Stormberg type *Schizoneura krasseri*.

The fragments of broad Equisetaceous stems are too small and imperfect to admit of a complete diagnosis: they are characterised by the numerous internodal ridges which often pursue a straight course across the nodal region and by their long internodes, which reached a length of at least 7 cm. The small piece of ribbed stem figured by Feistmantel † from the Stormberg beds shows broader and more prominent ridges than the specimens represented in figs. 5 and 6. The Scanian Rhætic species *Schizoneura hoerensis* His.‡ resembles the figured specimens in the narrow and numerous ribs, and a piece of broad stem described by Zeiller § from Tonking as *Phyllotheca indica* Bunb. is also very similar to the examples shown in figs. 5 and 6.|| Specimens which may well be identical with the South African species are figured by Krasser from China as Equisetaceous stems probably referable to *Schizoneura*,¶ and by Schenk as *Schizoneura* sp.** from Rhætic rocks of Persia. Some of Feist-

* Zeiller (02[2]), pls. xxxvii., xxxviii.

† Feistmantel (89), pl. iii., fig. 9.

‡ Nathorst (78), pl. x., figs. 6–8. See also Nathorst (78), pl. i., figs. 1–4.

§ Zeiller (82), pl. x., fig. 1.

|| See note. p. 75.

¶ Krasser (00), pl. iii., figs. 1–3*a*.

** Schenk (87), pl. viii., figs. 46, 48.

mantel's figures* of the stems of *Schizoneura gondwanensis* agree very closely with figs. 5 and 6, pl. ix., and the fragmentary leaf-like impressions with dark veins found in association with the African stems are very similar to the Indian specimens of *Schizoneura* leaves.

The largest specimens of *Schizoneura krasseri* that I have seen is one in the British Museum Collection (V. 2413); it consists of a flattened stone-cast having a diameter of 10 cm. One node is preserved, and an internode reaches a length of 20 cm.

Plate IX., fig. 5 (308d).

Several flattened impressions of broad stems; the one figured has a breadth of 6 cm., but is imperfect. The internode extends for a length of 7 cm., but only one node is seen on the specimen. The preservation of the nodal region is not sufficiently good to show the structural details; many of the ridges are seen to be continued in a straight line across the node, but some show a distinct alternation.

Plate IX., fig. 6 (487d).

A portion of an imperfect broad stem showing a rather more clearly defined nodal region with a few small and indistinct protuberances probably marking the position of leaf-traces. On the reverse side of the specimen there are a few fragments of what may be leaves with broad parallel veins about 2 mm. apart; possibly these may be leaves of *Schizoneura*.

Other Specimens: B, good impression of stem showing a node and indications of leaf-traces; 104a, a piece of a narrower stem, 3 cm. broad, showing a nodal construction; 481d, 484d (roots?); 485d, impressions of stems, and roots?; 488d (roots?); 489d, 494d, a well-preserved specimen; the surface of the ribs shows fine longitudinal striations, which no doubt indicate a woody structure; 496d, ribs rather broader.

Genus STROBILITES Schimper and Mougeot.

Strobilites sp.

(Possibly the strobilus of *Schizoneura Krasseri*, the plant represented in pl. ix., figs. 5, 6.)

The imperfectly preserved specimen shown in fig. 3, pl. ix. (486d, 495d) is undoubtedly a strobilus bearing crowded appendages, pro-

* Feistmantel (80), pls. i., ii. ix., &c.

bably of the nature of distally expanded sporangiophores; but the preservation is unfortunately too imperfect to admit of any satisfactory diagnosis. The cone itself is incomplete and does not show the apical portion; it is 6 cm. long and slightly more than 2 cm. broad; the surface is rough and uneven, but shows here and there distinct indications of polygonal protuberances and a few small oval bodies, which may be the terminations of sporangiophores bearing sporangia. The peduncle is represented by an axis 6 mm. broad showing longitudinal striations on its surface. The form of the cone, the appearance of the polygonal prominences and depressions, and its association with stems like those shown in pl. ix., figs. 5 and 6, lead me to regard the specimen as a strobilus of an Equisetaceous plant, possibly *Schizoneura krasseri*.

Group FILICALES.

FERNS OF UNCERTAIN SYSTEMATIC POSITION.

Genus THINNFELDIA Ettingshausen.

This generic name was instituted in 1852 for some specimens from the Lias of Steierdorf and defined as follows:—*

"Rami teretes vel subalati. Folia disticha, alterna oppositave, rhomboidea, ovalia vel lanceolata vel linearia, flabellatim vel pinnatim venosa."

Ettingshausen's species *Thinnfeldia rhomboidalis* closely resembles the South African forms, and represents a typical example of the genus. The comparison made by the authors of the genus with the New Zealand Conifer *Phyllocladus* has not been borne out by the investigation of more recently acquired specimens.

In 1853 Andrae substituted Brongniart's genus *Pachypteris* for *Thinnfeldia* and spoke of *T. rhomboidalis* as *Pachypteris thinnfeldia* And.† The genus *Pachypteris* is defined by Brongniart as being characterised by entire pinnules without veins or with a single vein, and is referred by him to the ferns. Zigno's large and well-preserved specimens from the Oolitic rocks of Italy placed in his genus *Dichopteris* are no doubt generically identical with *Pachypteris*, but in the Italian examples‡ the pinnules are traversed by several

* Ettingshausen (52), p. 2.
† Andrae (53), p. 43.
‡ Zigno (56), pls. xii., xiii., xv.

divergent veins. Species of *Pachypteris* or *Dichopteris* in which the ultimate segments possess spreading and forking veins bear a marked resemblance to *Thinnfeldia;* it is probable that the two genera are very closely allied.

Schimper, in the second volume of the "Traité de paléontologie végétale,"* extends Ettingshausen's definition, and compares *Thinnfeldia* with *Pachypteris* and *Cycadopteris*. In 1867 Schenk described specimens of *Thinnfeldia* from the Rhætic beds of Franconia and published figures of the epidermal cells and stomata; he placed the genus among the Cycads. †

Bornemann,‡ in 1856, published figures of the epidermis of *Scytophyllum bergeri* Born., a plant bearing a close resemblance to *Thinnfeldia*, which may be compared with the drawings reproduced in pl. ix., figs. 7 and 8. Solms-Laubach § notes the occurrence of stomata on both sides of the lamina of *Thinnfeldia* as a character which may possibly indicate that the genus may not be a fern; in other respects the fern-like nature appears to be clearly indicated.

Another genus—*Ptilozamites* of Nathorst—differs from *Thinnfeldia* in the greater parallelism of the veins in the pinnules, but in other respects there is a striking agreement between the two genera, and it is doubtful if there are sufficient grounds for regarding the slight difference in venation characters as more than a specific distinction. A comparison of Nathorst's figures of species of *Ptilozamites* from the Rhætic of Bjuf ‖ and the Thinnfeldias of South Africa represented in pls. vii. and viii. demonstrates the similarity between the Northern and Southern types. Gutbier's Permian species, *Odontopteris reichiana*,¶ is another type which exhibits a very close resemblance to *Thinnfeldia*. Another plant which I venture to think should not be separated from *Thinnfeldia* has been described and figured by Sellards from Permian rocks of Kansas as *Glenopteris simplex*.** In speaking of the characters of this new genus *Glenopteris* the author notes its resemblance to *Lomatopteris* and *Cycadopteris*, but does not refer to *Thinnfeldia*. It is not clear that the institution of *Glenopteris* was a necessary addition to palæobotanical nomenclature.

Similarly some of the Italian species of *Dichopteris* of Zigno and species referred by Saporta†† to *Lomatopteris* and *Cycadopteris* may well be generically identical with Ettingshausen's genus *Thinnfeldia*.

* Schimper (70), p. 494.
‡ Bornemann (56), pl. vi., figs. 1–6.
‖ Nathorst (78), pls. xii., &c.
** Sellards (00), pl. xxxix.
† Schenk (67), p. 105, pl. xxvii.
§ Solms-Laubach (91), p. 140.
¶ Weiss (69), pl. i., figs. 3–9.
†† Saporta (73), p. 340.

Until we find well-preserved fertile specimens of *Pachypteris*, *Ptilozamites*, *Thinnfeldia*, and other genera we cannot hope to define with accuracy their systematic positions or relationships. One impression derived from a comparison of Nathorst's *Ptilozamites*, of which there is an exceedingly good series in the Stockholm Museum, with the Southern Hemisphere Thinnfeldias is that the differences between the two genera have been exaggerated, and geographical separation has been allowed too much weight in influencing the choice of distinct generic designations. On the other hand, it is clear that certain authors have unduly extended the application of Ettingshausen's *Thinnfeldia*.

The most satisfactory evidence so far published as to the systematic position of *Thinnfeldia* has been furnished by Raciborski in his description and illustration of a specimen of *T. rhomboidalis* from Jurassic rocks of Poland: this author gives drawings of a leaflet bearing the impression of what appears to be a circular sorus showing the boundaries of individual sporangia, but the material is too imperfect to afford any indication as to the nature of the sporangia.* In addition to the evidence afforded by the Polish specimen I may mention a specimen in the British Museum (V. 5950) in which the broadly linear segments of a *Thinnfeldia* pinna show two rows of contiguous polygonal or oval prominences, one on either side of the midrib, which agree in size and shape with the sori of certain ferns; but until we obtain sporangia we cannot speak with certainty as to the precise nature of the fertile frond. My friend Mr. Arber, of Cambridge, hopes to publish a more detailed account of the British Museum specimen.

Thinnfeldia odontopteroides (Morris).

Plate VII., figs. 1, 7, 8, 8*a*; Plate VIII., figs. 7, 8; Plate IX., figs. 7, 8; Plate XI., fig. 2.

Text-figure 6.

1845. *Pecopteris odontopteroides* Morris, in Strzelecki's New South Wales, p. 249, pl. vi., figs. 2–4.

1847. *Gleichenites odontopteroides* McCoy, Annals Mag. Nat. Hist., vol. xx., p. 147.

1872. *Pecopteris odontopteroides* Carruthers, Quart. Journ. Geol. Soc., vol. xxviii., p. 355, pl. xxvii., figs. 2, 3.

* Raciborski (94), pl. xx., figs. 1, 2, p. 206. See also Zeiller (00), p. 97.

1875. *Pecopteris odontopteroides* Crépin, Bull. Acad. R. Belgique, vol. xxxix., p. 258 (plate).
1876. *Thinnfeldia crassinervis* Geinitz, Palæont. Suppl., iii., p. 4., pl. i., figs. 10–16.
1883. *Thinnfeldia odontopteroides* Tenison-Woods, Proc. Linn. Soc. N. S. Wales, vol. viii., p. 103.
T. odontopteroides var. *falcata*, p. 107, pl. viii., fig. 1.
1888. *Thinnfeldia odontopteroides* Szajnocka, Sitzb. K. Akad. Wiss. Wien, vol. C. Abth. i., p. 10, pl. i., figs. 1–4.
1889. *Thinnfeldia odontopteroides* Feistmantel, Abh. K. böhm. Ges. Wiss. Bd. III., Folg. vii., p. 62, pls. 1–3.
1890. *Thinnfeldia odontopteroides* Feistmantel, Mem. Geol. Surv. N. S. Wales, p. 101, pls. xxiii.–xxv., xxviii., xxix.
1892. *Thinnfeldia odontopteroides* Jack and Etheridge, Geol. and Palæont. Queensland, pl. xvii., fig. 1.
1902. *Thinnfeldia odontopteroides* Arber, Quart. Journ. Geol. Soc., vol. lviii., p. 2.

In addition to the references given in the synonomy, the following may be added as types of *Thinnfeldia* which may be either specifically identical with *Thinnfeldia odontopteroides* or at least very closely allied forms:—

Thinnfeldia rhomboidalis Ettingshausen.*
T. lancifolia as figured by Morris,† Szajnocha,‡ and Solms-Laubach.§
T. tenuinervis Geinitz.‖
T. indica Feistmantel.¶
Odontopteris macrophylla Curran.**
Thinnfeldia falcata Tenison-Woods.††
Gleichenia lineata Tenison-Woods.††

Frond bipinnate, rachis stout, occasionally bifurcating into two linear pinnæ inclined to one another at a small angle (pl. vii., fig. 1). The pinnæ bear crowded pinnules with apparently a thick lamina; the pinnules vary considerably in size, shape and venation, they may be stout and broad and almost semicircular in form, deltoid or broadly oval with slightly divergent forked veins passing into broad linear segments with a well-marked midrib giving off forked secondary veins at an acute angle. The pinnules are confluent at the base. In the

* Ettingshausen (52).
‡ Szajnocha (88).
‖ Geinitz (76), pl. i., fig. 17.
** Curran (85), pl. ix., fig. 3.
† Morris (45), pl. vi.
§ Solms-Laubach (99), pl. xiv., fig. 2.
¶ Feistmantel (77), pls. xxxix. and xlvi.
†† Tenison-Woods (83).

shorter pinnules the lamina is traversed by several slightly diverging veins which spring separately from the rachis, but as the pinnules become larger the veins tend to converge in the basal portion of the lamina, forming a midrib (pl. vii., fig. 8). In the apical portion of the pinnæ the divisions between the segments become shallower and the apex consists of a bluntly terminated entire lamina. Epidermis composed of polygonal cells or—above the veins—of oblong rectangular cells with very slightly undulating walls. Stomata not very numerous, occurring on both the upper and lower epidermis, probably slightly sunk, bordered by two or four cells which may be subsidiary cells above the true guard-cells; the pore of the stoma is bounded by two crescent-shaped cuticular ridges which may belong to the guard-cells.

The specimens from the Stormberg beds are all sterile, and none have been found showing the habit represented in Feistmantel's figures of Australian examples.

The most common form of pinna and pinnules is that represented in fig. 1, pl. vii., in which the segments have no midrib but agree in their venation with the genus *Odontopteris*. A few specimens occur in which the pinnules are broadly linear and provided, at least in the basal portion, with a midrib: these examples (pl. vii., figs. 7, 8) are, I believe, specifically identical with those bearing shorter and broader segments. Morris * referred the pinnæ with longer segments to a variety—var. *lancifolia*, and by other authors this form has been raised to specific rank.

Geinitz † figures an example of a pinna with longer pinnules from the Argentine which he names *Thinnfeldia tenuinervis*, and Solms ‡ refers a Chilian specimen of Rhætic age to *T. lancifolia* Morris.

Szajnocha § also adopts a distinctive name, *T. lancifolia*, for Argentine Rhætic specimens with linear pinnules. The occurrence of intermediate forms of pinnules connecting those having almost parallel veins with the longer ones, in which a midrib is well defined, leads me to include both under one specific name. A similar course is adopted by Feistmantel ‖ in his Australian monograph. The Rhætic specimens described by Nathorst from Scania and placed in the genus *Ptilozamites* exhibit a similar variation in the form and size of the ultimate segments.

The Queensland specimen figured by Carruthers is in the British

* Morris (45), pl. vi., fig. 4.
† Geinitz (76), pl. i., figs. 17, 18.
‡ Solms-Laubach (99), pl. xiv., fig. 2.
§ Szajnocha (88).
‖ Feistmantel (90), pl. xxix.

Museum Collection (V. 4197); it is clearly identical with the South African examples, but the details are less distinct in the specimen than in the published figure.

Plate VII., fig. 1 (21e).

Branched piece of frond; the unbranched portion shown in the figure has a length of 11·5 cm. and is incomplete distally. The longest segment is 1·5 cm. long and 6 mm. broad. The pinnules show very clearly the slightly divergent and forked veins and the leathery texture of the lamina.

Plate VII., figs. 8, 8*a* (45e).

Preserved as a clearly defined brown impression with numerous fragments of pinnæ with pinnules varying considerably in size; the figured segments show the midrib and lateral veins very clearly.

Plate VII., fig. 7 (477d).

An indistinct impression in oxide of iron on sandstone. The linear pinnules are confluent at the base, forming a narrow wing to the rachis. A midrib is seen in the lower part of some of the segments, also oblique secondary veins. Associated with fragments of pinnæ bearing the shorter and broader type of segment.

Plate VIII., fig. 7 (22e).

A piece of a pinna with larger segments (1·5 cm. × 10 mm.); also a forked pinna with smaller pinnules.

Plate VIII., fig. 8 (d).

A specimen on a piece of shale from Cyphergat showing much smaller pinnules; associated with other specimens of the type represented in fig. 1, pl. vii.

Plate IX., fig. 7 (A).

A few epidermal cells of a small leaflet of *Thinnfeldia odontopteroides*, showing the slightly wavy form of the walls, and four cells surrounding a stomatal pore. The narrower central part of the pore is bounded by the remains of delicate cell membranes with thickened borders which possibly represent cuticular ridges of the guard cells. The appearance of the stomata suggests that the guard-cells are slightly sunk.

Plate IX., fig. 8 (B).

A fragment showing the thickened cuticular edge of a leaflet and a single stoma with two crescent-shaped cuticular ridges bordering the pore.

Plate XI., fig. 2 (44e).

A forked portion of a frond showing a variation in the form of the pinnules, some of which are identical with those represented in fig. 1, pl. vii., while others are longer and illustrate the convergence of the veins to form a midrib in the basal portion of the segments.

Text-figure 6 (× 1½).
Thinnfeldia odontopteroides (Morr.).
From a specimen from Cyphergat in the British Museum (V. 2490).

Text-figure 6. The British Museum specimen from Cyphergat shows the venation of the pinnules very clearly, it is undoubtedly specifically identical with the example represented in pl. vii., fig. 1.

Other Specimens : A. Fragments from Cyphergat; 4, 5 (associated with a piece of *Baiera*). 23e, specimen with pinnules intermediate between those shown in pl. vii., figs. 1 and 8; associated with *Stenopteris elongata* (Carr.) and *Callipteridium*. 24e, 25e, 26e

(with *Tæniopteris*), 28e, 29e, 30e, 32e, 33e—several fragments, one showing the apical portion of a pinna; 35e, 36e—a good specimen of a forked portion of a frond; 42e, 43e, 309d, including a good impression of the apex of a pinna, 310d, 312d, 313d, 315d, 316d, 475d, 476d, 478d, 479d.

Thinnfeldia rhomboidalis Ettingshausen.

Plate VIII., fig. 1.

1852. *Thinnfeldia rhomboidalis* Ettingshausen, Abk. k.-k. geolog. Reichs. Wien, Bd. I., Abt. iii., p. 2, pl. i., figs. 4–7.
1867. *Thinnfeldia decurrens* Schenk, Foss. Flor. der Grenzschichten, p. 114, pl. xxvi., figs. 1–5.
T. rhomboidalis, *ibid.*, p. 116, pl. xxvii., figs. 4, 5.

Similar in habit to *Thinnfeldia odontopteroides*, but characterised by the longer broadly linear segments decurrent by the lower margin on the rachis, the upper edge of the base being separated from the rachis by a distinct sinus; a well-marked midrib giving off oblique forked veins, the lower basal portion of the segments contains a few curved veins which enter the lamina direct from the rachis.

The single fragment from Stormberg represented in pl. viii., fig. 1 may belong to a larger pinna of *Thinnfeldia odontopteroides*, or it may be included under Ettingshausen's species* as more clearly resembling the Steierdorf examples than the typical forms of Morris's species.

Schenk's figures of *T. rhomboidalis*† represent specimens which cannot be distinguished from that shown in pl. viii., fig. 1. An example of *Thinnfeldia* from the Burrum Coalfield, Queensland, referred by Jack and Etheridge‡ to *T. media* Ten.-Woods, is probably identical with *T. rhomboidalis*.

Plate VIII., fig. 1 (C).

This fragment shows very clearly the form and venation of the segments; the agreement between this specimen and Schenk's *Thinnfeldia decurrens* is exceedingly close. A fragment of *Stenopteris elongata* (Carr.) is seen resting on the *Thinnfeldia*.

* Ettingshausen (52), pl. i.
† Schenk (67), pl. xxvii., figs. 4, 5.
‡ Jack and Etheridge (92), pl. xviii., fig. 10.

Genus CALLIPTERIDIUM Weiss.

Callipteridium stormbergense sp. nov.

Plate VII., figs. 4–6*a*; Plate VIII., fig. 5.

Frond bipinnate, rachis stout; pinnæ alternate, linear, tapering to an acuminate apex. Pinnules linear, entire or serrate, becoming more crowded in the distal region of the pinnæ and near the apex of the frond, confluent basally; the rachis bears pinnules that extend upward on to the lower side of the pinnæ. Venation of the *Cladophlebis* type, approaching the *Sphenopteris* type in the smaller fronds (pl. viii., fig. 2).

The Rhætic species figured by Jæger as *Aspidioides stuttgardiensis*,* by Nathorst † from Scania as *Lepidopteris ottonis* Goepp., and by Schenk as *Asplenites ottonis* ‡ resembles the African fern in having pinnules on the rachis, but differs in the larger ultimate segments. This European type is, however, characterised by the occurrence of numerous scales on the rachis, a feature not exhibited by the Stormberg plant. A French species figured by Saporta as *Lomatopteris liasina* Morr § affords another example of a bipinnate frond with pinnules springing from the main rachis.

In order to avoid the institution of a new generic name, I propose to speak of the African fern as *Callipteridium stormbergense*. The fragment of a *Cladophlebis* figured by Feistmantel as *Asplenium*, cf. *nebbense*,‖ may possibly be a piece of a large pinna of *Callipteridium stormbergense*, but the specimen is too small to determine.

One striking feature of the bipinnate frond shown in fig. 6, pl. vii., is the occurrence of pinnules on the main rachis; in other respects the characters appear to be such as might be expressed by the use of the generic name *Cladophlebis*. The Palæozoic type *Callipteris conferta*¶ bears pinnules on the rachis, and a similar character is seen in fronds included in Weiss' genus *Callipteridium;*** similarly a fern named by Heyer to *Callipteris schenkii* †† exhibits the same features but bears lobed pinnules.

A fragment figured by Szajnocha ‡‡ from Cacheuta (Argentine) as

* Jæger (27), pl. viii.
† Nathorst (78), pl. ii., fig. 1.
‡ Schenk (67), pls. xi. and xiv.
§ Saporta (91), pl. lxvii., fig. 6.
‖ Feistmantel (89), p. 68, pl. ii., figs. 12, 12*a*.
¶ See Schimper (74), Atlas, pl. xxxii., fig. 2. See also Fontaine and White (80), pl. xi., figs. 1–4.
** Zeiller (00), p. 92, fig. 92.
†† Heyer (84).
‡‡ Szajnocha (88) pl., i., fig. 8.

Pecopteris schoenleiniana Brongn. bears a resemblance to the Stormberg plant, but it is too small to determine.

Plate VII., fig. 6 (39e).

Rachis stout, 11·5 cm. long. The linear confluent pinnules are for the most part entire, but on the lower pinnæ some show a distinct serrate margin (fig. 6*a*). In the apical region the pinnules are more crowded and gradually pass into segments with a serrate margin. The venation is obscure, but apparently of the *Cladophlebis* type. The pinnules on the lower side of the pinnæ pass on to the rachis, where they occur as segments of varying size and shape.

Associated with fragments of *Thinnfeldia*.

Plate VII., fig. 4 (10).

Pinnules enlarged, showing a well-defined midrib and lateral veins.

Plate VII., fig. 5 (31e).

The apex of a frond, showing the passage of pinnules into a terminal acuminate lamina with a serrate edge.

Plate VIII., fig. 2 (46e).

Habit similar to that of the larger frond shown in fig. 6, pl. vii. The pinnæ are more crowded, and the segments little more than well-marked serrations. Venation clearly preserved, each pinnule receives a vein which gives off a few branches at an acute angle. The lowest segment on the pinnæ tends to be decurrent on the main rachis.

Other Specimens: 8, small pinnæ with crowded pinnules, pinnules occur also on the main rachis; 40e, a portion of a frond rather less than that shown in fig. 6, pl. vi., and intermediate between that specimen and the still smaller example represented in fig. 2, pl. viii. 480d, an indistinct impression on sandstone of part of a large frond; associated with *Thinnfeldia*.

Genus TÆNIOPTERIS.

Tæniopteris carruthersi Tenison-Woods.

Plate VIII., figs. 5, 6.

1872. *Tæniopteris Daintreei* Carruthers, Quart. Journ. Geol. Soc., vol. xxviii., pl. xxvii., fig. 6, p. 355.

1883. *Tæniopteris Carruthersi* Tenison-Woods, Proc. Linn. Soc. N. S. Wales, vol. viii., p. 117.

1889. *Tæniopteris Carruthersi* Feistmantel, Abh. k. böhm. Ges. Wiss., Bd. III., Folg. vii., p. 65, pl. ii., figs. 6–10.

? *T. Daintreei, ibid.*, p. 66, pl. ii., fig. 11.

1890. *Tæniopteris Carruthersi* Feistmantel, Mem. Geol. Surv. N. S. Wales, p. 115, pl. xxviii., fig. 7.

Frond simple, strong midrib from which numerous single or forked secondary veins are given off either at right angles or at a wide angle. The breadth of the lamina decreases gradually towards the petiole.

In 1872 Carruthers* referred some *Tæniopteris* leaves from Queensland to McCoy's species *T. daintreei*,† but as Tenison-Woods pointed out in 1883, McCoy's type is characterised by the narrow linear form of the frond and differs considerably from the broader form of leaf figured by Carruthers. The specimen described by Carruthers [in the British Museum Collection (V. 4199)] is clearly identical with those from South Africa figured by Feistmantel. A leaf from the Argentine named by Geinitz *Tæniopteris mareyiaca*,‡ bears a close resemblance to *T. carruthersi*, but there appears to be a slight difference in the venation. Some specimens from India referred by Feistmantel to *Tæniopteris vittata*,§ a species differing but slightly from *T. carruthersi*, are very similar to the type of frond shown in pl. viii., fig. 6. A Rhætic species from Scania, named by Nathorst *Tæniopteris immersa*,‖ may be identical with the South African fern; but the comparison of sterile fragments of *Tæniopteris* fronds can lead to no certain results.

Plate VIII., fig. 6 (497d).

Portion of leaf 8·5 cm. long and 3 cm. broad; the midrib is comparatively broad and well defined. The secondary veins are approximately 1 mm. apart or slightly closer.

Plate VIII., fig. 5 (14e).

This much narrower fragment is distinguished by the more open arrangement of the forked and simple lateral veins, but it may

* Carruthers (72).

† For figures of the true *Tæniopteris Daintreei* McCoy, see Oldham and Morris (63), pl. vi.; McCoy (74), pl. xiv.; Feistmantel (77[2]), pl. i., &c.

‡ Geinitz (76), pl. ii., figs. 1–3.

§ Feistmantel (76), pls. i., ii.

‖ Nathorst (78), pl. xix., fig. 6.

represent the lower and gradually tapering portion of *Tæniopteris carruthersi*. Compare Feistmantel's figures of narrower fronds referred to this species.*

Plate VIII., fig. 4 (1).

This specimen differs from that shown in fig. 6 (497d) in the greater inclination of the secondary veins and in the texture of the lamina, which gives the impression of being woolly. Possibly it would be wiser to distinguish this form by another specific name, but the apparent difference in texture may be due merely to the manner of preservation, and in any case the material is too meagre to be described under a new specific title.

Other Specimens : 2e and 3, half of a leaf lamina, similar to the specimen shown in fig. 4, but the veins are more clearly preserved and given off at a wider angle from the midrib; 9e, pieces of fronds, a broader fragment like that shown in fig. 6, and a narrower specimen with crowded veins; 10e, 27e, 466d, 498d, three pieces, one showing the gradual decrease in breadth of the lamina towards the base of the leaf.

Genus CHIROPTERIS Kurr.

This genus, instituted by Kurr for a leaf from Keuper beds near Stuttgart, is thus defined by Schimper :— †

"Frons petiolata, simplex, irregulariter inciso-digitata, coriacea. Nervi numerosissimi e basi radiantes, tenues, omnes, æquales vel loborum nervo medio distinctiore, repetito-dichotomi, anastomosantes, reteque anguste rhomboiderm efficientes."

We possess no satisfactory evidence as to the affinity of this genus. In form and venation *Chiropteris* agrees with the recent genus *Ophioglossum*, and on the strength of this resemblance it has been placed by some authors in the Ophioglossaceæ.‡

Zeiller § has also referred to the resemblance between *Chiropteris* and *Ophioglossum*, but a comparison based on form and venation only is in this case of little or no botanical value. The genus may at present be included provisionally among the ferns, with the reservation that we lack satisfactory evidence as to its taxonomic position. The leaves from the Kootanie group referred by Newberry

* Feistmantel (89), fig. 7.
† Schimper (69), p. 643; Atlas, pl. xliii.
‡ Schimper and Schenk (90), p. 152; Potonié (99), p. 91.
§ Zeiller (00), p. 55.

to *Chiropteris* should probably be included in a distinct genus, one of them—*C. spatulata*—may be a species of *Sagenopteris*.* The Chilian fossil referred by Solms-Laubach † to Kurr's genus differs in the form of the leaf and in the more crowded veins from the African species.

Chiropteris cuneata (Carruthers).

Plate IX., fig. 4.

1872. *Cyclopteris cuneata* Carruthers, Quart. Journ. Geol. Soc., vol. xxviii., p, 355, pl. xxvii., fig. 5.
1889. ? *Anthrophyopsis* sp. Feistmantel, Abh. k. böhm. Ges. Wiss. Folge, vii., Bd. III., p. 67, pl. ii., fig. 4.

Leaves cuneate in form, the lamina traversed by numerous spreading veins, dichotomously forked and occasionally anastomosing by oblique cross veins.

Carruthers thus defined the species *Cyclopteris cuneata*, which he founded on a specimen from the Tivoli Coal-mine, Queensland :—

"Form of the entire frond unknown ; pinnæ entire, large, cuneate, narrowed at the base, with the distal margins rounded ; veins delicate, once or twice dichotomously divided ; sometimes anastomosing once in their length near the middle of the pinna." ‡

The type-specimen in the British Museum (V. 4197) is accurately represented in Carruthers' figure ; the veins are very obscure. The anastomosing veins which are described by Carruthers and shown in the specimen represented in pl. ix., fig. 4, and still more clearly in a better specimen from the Stormberg beds in the British Museum Collection (V. 2498), render *Cyclopteris* unsuitable as a generic designation.

It is by no means unlikely that the fragment of a leaf figured by Feistmantel from Cyphergat as *Anthrophyopsis* (?) § may be identical with the plant represented in pl. ix., fig. 4. An imperfect specimen figured by Fontaine from North American Triassic beds ‖ as *Sagenopteris rhoifolia* bears a distinct resemblance to the Stormberg leaf.

Plate IX., fig. 4 (C).

The distal margin of the wedge-shaped leaf is rather torn and incomplete ; the thin lamina tapers towards the base, which is

* Newberry (91), p. 198, pl. xiv., figs. 1, 2, 10, 11.
† Solms-Laubach (99), pl. xiii., figs. 1–4.
‡ Carruthers (72), p. 355, pl. xxvii., fig. 5.
§ Feistmantel (89), p. 67, pl. ii., fig. 4. ‖ Fontaine (83), pl. xlix., fig. 5.

also only partially preserved. The veins are fairly distinct; they diverge from the base, forking and occasionally anastomosing by oblique cross-connections.

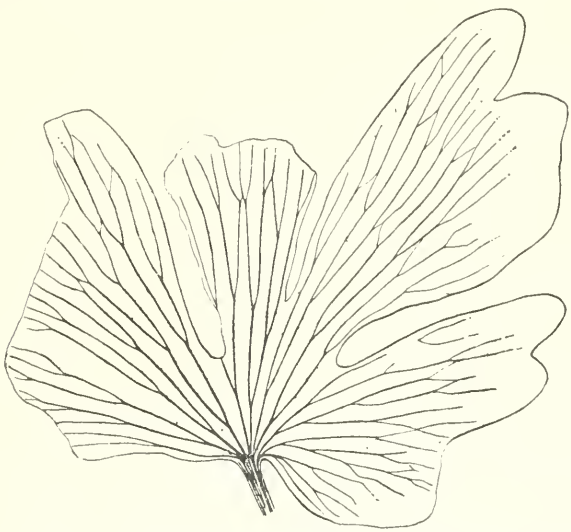
Associated with *Thinnfeldia* and *Phœnicopsis*.

Other Specimens : b. An impression similar to that figured (pl. IX., fig. 4); veins fairly clear. Associated with *Thinnfeldia* and *Phœnicopsis*.

Chiropteris zeilleri sp. nov.

Text-figure 7.

Leaf petiolate; lamina more or less orbicular, deeply lobed into broad segments with an irregularly lobed margin; veins spreading from the base, forked and anastomosing, forming long and comparatively broad polygonal meshes.



Text-figure 7. (Nat. size.)
Chiropteris zeilleri sp. nov. From a specimen from Cyphergat in the British Museum (V. 3268).

This species is founded on a single specimen from Cyphergat in the British Museum Collection (V. 3268), shown in text-figure 7. The type-specimen is an imperfect leaf showing the upper part of a petiole bearing a deeply lobed lamina, 7·5 cm. in depth and 8·5 cm. broad; the sinus on the right-hand side of the lamina is preserved intact, while those on the left are partially torn.

The veins, which are very clearly preserved, radiate from the apex of the leaf-stalk, and by the occasional anastomosis of adjacent forked branches, form long meshes.

In shape the leaf may be compared with small fronds of the recent fern *Dipteris*,* and with the fossil genera *Protorhipis* of Andrae and *Hausmannia* of Dunker, but the absence of veins in the meshes constitutes an important distinguishing feature. Some Jurassic Bornholm ferns figured by Möller in a recent paper and referred to *Hausmannia*,† but which I should prefer to assign to *Protorhipis*, illustrate the superficial resemblance of the *Dipteris* type of frond to *Chiropteris zeilleri*.

A fossil leaf with somewhat similar, but not identical, venation has been figured by Feistmantel from India as *Belemnopteris Woodmasoniana* ‡ and compared with the recent genus *Hemionitis*. The genus *Hemionitis*,§ a typical American member of the Polypodiaceæ, is characterised by its palmate lamina and prominent ribs, thus differing from *Chiropteris*. The recent genera *Ophioglossum* and *Antrophyum* afford the nearest parallels as regards venation to the fossil frond, but we have absolutely no evidence as to the precise position of *Chiropteris*.

The specimens of *Chiropteris* figured by Bronn from the Lettenkohle beds ‖ differ from *C. zeilleri* in the much more numerous and crowded veins, which are not described as anastomosing, and in the apparently whorled disposition of the sessile leaves. I have named the Stormberg leaf after my friend Professor Zeiller of Paris, whose work has done so much to extend our knowledge of the vegetation of the Southern hemisphere.

GYMNOSPERMÆ.

Group GINKGOALES.

Genus BAIERA, Braun.

Baiera stormbergensis sp. nov.

Plate VIII., fig. 3.

Lamina deeply dissected into broad linear segments which are again subdivided distally into narrower linear lobes; veins com-

* Seward and Dale (01). † Möller (02). ‡ Feistmantel (80), pl. xliii. A.
§ Christ. (97), p. 57. ‖ Bronn (58), p. 143, pl. xii.

paratively few in the lower part of the lamina, but after repeated dichotomy they become more numerous in the upper part of the leaf, where they occur as crowded parallel veins slightly converging towards the tips of the narrow terminal segments. The whole lamina reached a length of 12 cm. or more and probably a breadth of 10 cm.

I have given a new specific name to the unusually large type of leaf represented in pl. viii., fig. 3; it might with equal propriety be included in the genus *Ginkgo*, as one occasionally finds large and deeply lobed leaves of the Maidenhair tree very similar to the example shown in the figure.*

The species described by Feistmantel from the Stormberg beds as *Baiera schenki* † may be merely a smaller form of *B. stormbergensis*, but the much greater breadth of the segments and the more open character of the venation constitute distinctive features. It is, however, by no means improbable that the narrower and broader forms may be found to be inseparable. Feistmantel's *B. schencki* bears a fairly close resemblance to *B. longifolia* Heer.‡

Other large leaves comparable with *B. stormbergensis* have been described by Shirley from Ipswich, Queensland as *Ginkgo simmondsi*, *Baiera ginkgoides* and *B. ipsviciensis*; § Ratte ‖ has also described a very large leaf from the Wianamatta shales under the name *Salisburia palmata*. It is possible that the large Australian leaves referred by Shirley to *Ginkgo simmondsi* and by Ratte to *Salisburia palmata* may be identical with the Triassic American type *Baiera multifida*.¶

Plate VIII., fig. 3 (x).

The lamina is incomplete, but reaches a length of 11 cm. The spreading and repeatedly forked veins are very clearly shown traversing the long lobes of the leaf, which is preserved in the form of a light brown impression, which suggests a thin lamina similar to that of *Ginkgo biloba*.

Other Specimen: 16c. A small specimen showing terminal portions of a leaf and slightly converging veins at the tips of the segments.

* Seward and Gowan (00), pl. x., fig. 63.

† Feistmantel (89), p. 72, pl. iii., figs. 1, 2, 5, 6.

‡ Heer (77), pls. vii.–x., xv. § Shirley (98). ‖ Ratte (88) (88²).

¶ Fontaine (83), pls. xlv.–xlvii. See also Seward and Gowan (00), p. 139, and Arber (02), pp. 4, 5.

? GINKGOALES.

Genus STACHYOPITYS Schenk.

Stachyopitys sp.

(Cf. *Sphenolepis rhætica* Geinitz).

Plate IX., figs. 2, 2*a*.

A fragment of a fertile shoot consisting of a fairly broad axis bearing lateral branches terminating in a cluster of obovate bodies arranged in apparent whorls.

The nature of the fossil represented in pl. ix., figs. 2, 4*a*, must be left in doubt; the single specimen is too incomplete to afford sufficient evidence as to its structure and affinity. A somewhat similar fragment is figured by Geinitz * from the Rhætic of San Juan (Argentine) as *Sphenolepis rhætica;* he describes the specimen as consisting of spherical or compressed cones bearing numerous spirally disposed woody scales of obovate form, their outer convex surface exhibiting indistinct and irregular longitudinal striæ or grooves. In size, and in the appearance of the cones, Geinitz's specimen agrees with that shown in fig. 2; but in the African example the scales occur in a single radiate series with portions of a superposed second series seen at *a*, fig. 2*a*.

Another fossil bearing a resemblance to the Stormberg specimen is that described by Schenk under the name *Stachyopitys preslii* † as male flowers of a Conifer from the Rhætic of Franconia; the chief difference between the German and African fossils is the smaller number of radiate appendages in the former. A Queensland fossil described by Shirley as *Stachyopitys annularioides* ‡ also agrees fairly closely with the Stormberg fragment, so far as it is possible to base an opinion on the somewhat crude drawings.

From Thuringian Permian rocks Potonié has figured fertile portions of *Pecopteris pinnatifida* (Gutb.) § which present an appearance similar to that of Schenk's *Stachyopitys preslii* and to the specimen shown in pl. ix., fig. 2.

Without expressing a definite opinion as to the botanical position of the fossil, it may be provisionally included in Schenk's genus *Stachyopitys*, with the suggestion that it may be a fragment of a

* Geinitz (76), p. 12, pl. ii., figs. 23, 24.
† Schenk (67), p. 185, pl. xliv., figs. 9–12.
‡ Shirley (98), p. 13, pl. xviii.
§ Potonié (93), pl. xviii., figs. 9, 10, and pl. x.

male flower of a member of the Ginkgoales. The radially disposed oval bodies may be microsporangia differing chiefly in their greater number from the usual type of the fossil male flowers of the Ginkgoales.

Plate IX., figs. 2, 2*a* (12).

A fragment of an axis 1·5 mm. broad with the remains of swollen lateral branches bearing circular rosettes 5 mm. in diameter consisting of fairly stout oval bodies attached by a narrow base and terminating in a bluntly rounded apex; these oval bodies are thick and rounded, and their surface shows a few longitudinal ridges. At *a* (fig. 2*a*) one sees the remains of other similar appendages superposed on the lower and more perfectly preserved ones.

PLANTS OF DOUBTFUL POSITION.

Genus PHŒNICOPSIS Heer.

In instituting this genus for Jurassic specimens of linear leaves from Siberia, Heer defined it as follows:—

"Folia coriacea, numerosa, in ramulo abbreviato caduco fasciculata, squamis compluribus persistentibus cincta, sessilia vel in petiolum brevem sensim attenuata, indivisia, multinervia, nervis simplicibus, parallelis, densis." *

We have no satisfactory evidence as to the botanical position of *Phœnicopsis*, but it has been referred to by Heer and other authors as closely allied to *Baiera* and possibly a member of the Ginkgoales.

Phœnicopsis elongatus (Morris).

Plate IX., figs. 1, 9, 10.

1845. *Zeugophyllites elongatus* Morris, in Strzelecki's New South Wales, p. 250, pl. vi., figs. 5, 5*a*.
1882. Cf. *Nœggerathiopsis Hislopi* Zeiller, Ann. des Mines, vol. ii. [8], pl. xii., fig. 11.
1889. *Podozamites* (*Zeugophyllites*) *elongatus* Feistmantel, Abh. K. böhm. Ges. Wiss., Bd. III., Folg. vii., p. 68, pl. ii., fig. 13; pl. iii., figs. 3, 4, 7.

Leaves linear, reaching a length of more than 16 cm.; the lamina is usually gradually tapered to an acuminate termination which may

* Heer (77), p. 49.

represent the basal end, but occasionally the leaf ends in a bluntly rounded apex which may be the distal termination.* Veins numerous, parallel, usually simple and not dichotomously branched. The numerous parallel veined linear leaves from Cyphergat, of which portions are shown in pl. ix., figs. 1 and 9, agree closely with Morris's species, *Zeugophyllites elongatus*, from the Jerusalem Basin, Tasmania.† The type-specimen of Morris's Jerusalem Basin plant, *Zeugophyllites elongatus*, which has recently been found by Mr. Arber in the British Museum Collection (V. 7512), convinces me of the identity of the Tasmanian and South African leaves.

The same name has been applied by Szajnocha‡ to a fragment from Cacheuta, which may not, however, be identical with Morris's type. Some specimens of linear leaves from South America in the British Museum Collection are undoubtedly identical with Morris's species. Feistmantel has figured several leaf fragments from the Stormberg beds which he speaks of as *Podozamites* (*Zeugophyllites*) *elongatus* (Morris);§ these are no doubt identical with the specimens represented in pl. ix., figs. 1, 9 and 10. It is possible that these leaves may be correctly referred to the genus *Podozamites*, but I am disposed to regard them as more probably examples of Heer's genus *Phœnicopsis*, similar to *P. speciosa* of Jurassic age.|| Krasser has figured several leaves very similar to mine from China which he refers to a new species *Phœnicopsis media*¶; one of his figures shows clearly that the leaves converge in groups to a common point of origin, but in the scattered fragments from Cyphergat it is impossible to recognise any such orderly arrangement. It is very difficult to determine with any degree of accuracy isolated leaves of the type of *Phœnicopsis* or *Nœggerathiopsis*; Zeiller's Tongking specimens may, I believe, be identical with Morris's species from New South Wales, but as Prof. Zeiller points out, in a letter written in reply to my suggestion, there is no evidence in the specimens he has seen to warrant the conclusion that they were borne in bundles like Heer's examples of *Phœnicopsis*. A similar leaf is figured also by Broun from the Lettenkoble of Raibl** as a monocotyledonous leaf. The bluntly terminated leaf fragment from Molteno shown in fig. 10

* Cf. Heer (77), pls. xxviii., xxix.
† Morris, in Strzelecki (45), p. 250, pl. vi., figs. 5, 5*a*.
‡ Szajnocha (88), pl. ii., fig. 4.
§ Feistmantel (89), p. 68, pl. ii., fig. 13; pl. iii., figs. 3, 4, 7.
|| Heer (77), pls. xxviii., xxix.
¶ Krasser (00), pl. iii., fig. 4; pl. iv., fig. 2.
** Bronn (58), p. 135, pl. vii., fig. 4.

suggests a comparison with the genus *Podozamites*, but this occurs in association with gradually tapered leaves like that represented in fig. 9, and the difference in the method of termination is in itself hardly a sufficient reason for the separation of the two forms.

With the exception of the forked vein shown in fig. 10, pl. ix., near the apex of the specimen, I have not detected any certain indication of the parallel veins in these leaf fragments from Cyphergat and Molteno; in *Nœggerathiopsis* leaves of similar form to that shown in pl. ix. figured by Feistmantel,* Zeiller,† and other authors the veins are dichotomously branched in their course through the lamina, and I have no hesitation in expressing the opinion that the African specimens should not be referred to that genus. Kurtz ‡ has recently expressed a similar opinion as to the difference between the true *Nœggerathiopsis* and Morris's *Zeugophyllites elongatus*.

Mr. Arber § has also drawn attention to a confusion between *Nœggerathiopsis* and *Zeugophyllites*.

Plate IX., fig. 1 (C).

An imperfect leaf 16 cm. long, and with an approximately uniform breadth of 1·2 cm. The lamina between the fairly broad veins is finely striated, the striæ no doubt representing hypodermal strands of mechanical tissue.

Plate IX., fig. 9 (d).

The figure represents the gradually tapered (basal?) end of an incomplete leaf 10.5 cm. long.

Plate IX., fig 10 (69).

The blunt apex of a leaf from Molteno showing the converging terminations of the veins. The venation is less clearly seen in this specimen than in the other figured pieces. Acuminately pointed leaves similar to the specimen from Cyphergat represented in fig. 9 occur on the same piece of rock.

* Feistmantel (80), pl. xlv. A.

† Zeiller (82), pl. xii., fig. 11.

‡ Kurtz (03), p. 25.

§ Arber (02), p. 18.

Genus STENOPTERIS Saporta.

Stenopteris elongata (Carruthers).

Plate VII., figs. 2, 3.

Plate XI., fig. 3.

1872. *Sphenopteris elongata* Carruthers, Quart. Journ. Geol. Soc. vol. xxviii., p. 355, pl. xxvii., fig. 1.
1883. *Sphenopteris elongata* Tenison-Woods, Proc. Linn. Soc. N. S. Wales, vol. viii., p. 92.
Trichomanites spinifolium, *ibid.* p. 95, pl. iii., fig. 7.
1888. *Sphenopteris elongata*, Szajnocha, Sitzb. Kais. Akad. Wiss. Wien., Bd. XCVII., Abth. i., p. 5., pl. ii., fig. 2.
1889. *Sphenopteris elongata* Feistmantel, Abh. k. böhm. Gess. Wiss., Bd. III., Folg. vii., p. 61.
1890. *Sphenopteris elongata* Feistmantel, Mem. Geol. Surv. N. S. Wales, p. 90.
Trichomanites spinifolium, *ibid.* p. 95.
1892. *Trichomanites spinifolium* Jack and Etheridge, Geol. Pal. Queensland, p. 315, pl. xviii., fig. 8.
1898. *Trichomanites elongata* var. *spinifolia*, Shirley, Bull. no. 7, Geol. Surv. Queensland, p. 19, pl. x., fig. 3.

Fragments of a repeatedly branched narrow woody axis, the ultimate branches alternate, linear or short and pointed. The linear branches may show what appears to be a comparatively broad midrib (pl. xi., fig. 3), but usually there is no clear indication of a median vein. In 1872 Carruthers described a plant from the Tivoli Coal-mine, Queensland, as *Sphenopteris elongata*, which he defined as follows :—

"Frond dichotomously divided, each division irregularly pinnate; pinnæ simple, bifurcate, or irregularly pinnate; segments narrow linear, slightly tapering upwards to the somewhat blunt apex; the single midrib sending out simple branches, which run along the middle of each segment." *

Carruthers mentions the occurrence of sori as small oval markings scattered irregularly on either side of the midrib, but no trace of such markings are shown in the published figure. In some of the fragments of this plant in the British Museum Collection the central rib, which stands out clearly in Carruthers' figure, is much less distinct

* Carruthers (72), p. 355, pl. xxvii., fig. 1.

and the winged membranous border represented in the drawing is not shown in the specimens that I have examined. A few of the Tivoli specimens in the British Museum are characterised by more numerous lateral branches and form connecting links between the types represented in pl. vii., figs. 1*a* and 3.

Szajnocha * refers a small specimen from Argentine Rhætic beds to Carruthers' species, but his material is too meagre to afford additional evidence as to the nature of the plant.

There can be no doubt as to the identity of the specimens shown in pl. vii., figs. 2, 3, and pl. xi., fig. 3, with Carruthers' species, but I have no hesitation in describing the South African examples as too stiff and woody to be referred to *Sphenopteris*. There is no well-defined median rib in the majority of the specimens, but the striated appearance of the impression and the stout form of the branches point to a plant of more woody texture than the frond of a fern.

In all probability the specimen represented in pl. vii., fig. 3, is specifically identical with those represented in fig. 2. The smaller form with the pointed and shorter branchlets agrees very closely with some Australian fossils figured by Tenison-Woods † as *Trichomanites spinifolium* but afterwards referred by Shirley to *Trichomanites elongata*.‡ Feistmantel § records a specimen of Carruthers' species from the Hawkesbury beds of New South Wales, and adds that its occurrence in the African Stormberg beds might be expected seeing that it is a common plant in association with *Thinnfeldia* in Queensland and that it occurs with this genus also in South America.

It is difficult to decide what generic designation to apply to the specimens represented in figs. 2 and 3, pl. vii., and fig. 3, pl. xi. The genus *Sphenopteris* used by Carruthers is, I believe, inappropriate, as the nature of the fossils does not appear to me to favour their identification as ferns. The lateral branches seem to be identical in texture with the axis from which they spring, and in the smaller specimen (pl. vii., fig. 3) the small ultimate branchlets show no trace of a median vein but present a longitudinally striated appearance (fig. 3*a*) suggesting a woody texture. I am unable to recognise any indication of scale-leaves, nor do there appear to be any transverse divisions or constrictions. Some specimens figured by Saporta from the Kimeridgien of France and placed by him in his genus *Stenopteris* agree closely with the African plant in habit, but differ apparently in the presence of a more distinct median vein and in the

* Szajnocha (88), pl. 11, fig. 2.

‡ Shirley (98), pl. x., fig. 3, p. 19.

† Tenison-Woods (83), pl. iii., fig. 7.

§ Feistmantel (89), p. 61.

membranous border of the linear segments. On the other hand, Saporta describes the fossils as having an "evidently coriaceous texture," * and he suggests the probability of *Stenopteris* being more closely allied to the cycads than to the ferns. We may provisionally make use of Saporta's generic name, noting the absence of a well-defined median vein, a character included in the diagnosis of the genus as represented by the type *Stenopteris desmomera* of Kimeridge age.

Some figures published by Feistmantel under the name *Palissya* † bear a resemblance to *Stenopteris elongata*, but the Indian and African plants are probably not identical. A comparison may also be suggested between the specimen shown in fig. 3, pl. vii., and Feistmantel's figure of *Pachyphyllum* (*Cryptomerites*) *divaricatum*,‡ but there is no evidence of the individuality of the ultimate branches in the African specimens suggesting their identity with the leaves of *Cryptomerites*.

Such specimens as that shown in fig. 2, pl. vii., might be expected to show indications of nodal regions. The appearance of the fragments recalls that of a xerophytic shrubby plant with branch-like leaves or with branches which played the part of leaves, as in the recent genus *Psilotum*.

A plant of somewhat similar form, but not identical, has been described from English Wealden strata as *Becklesia anomala*. §

Another genus comparable with Carruthers' *Sphenopteris elongata* is Schenk's *Frenelopsis*, but the well-marked nodal regions in that genus afford a distinguishing feature.

Plate VII., fig. 2 (21e).

A branched axis 11 cm. long, of woody texture. I can detect no distinct trace of a single median rib, but here and there a slight indication of a central ridge or depression may be seen. No trace of leaves or of nodal lines or constrictions. None of the branches are complete.

Plate VII., figs. 3 and 3*a* (B.)

A graphitic impression on a dark slaty rock. The axis of the lateral branches is represented by a fairly distinct median rib, but in the ultimate segments, which are for the most part entire but in a few instances lobed, there is no median vein. Fig. 3*a* shows an

* Saporta (73), p. 290, pl. xxxii.

‡ Feistmantel (76), pl. x. fig. 1.

† Feistmantel (76), pls. xi. and xii.

§ Seward (95), p. 179, pl. xiv.

ultimate segment slightly enlarged with numerous irregular longitudinal striations.

Other Specimens: 17e, a fragment showing the termination of a lateral branch; 38e

Plate XI., fig. 3 (6).

A fairly well-preserved impression of an axis bearing subopposite branches; both the main axis and the lateral members show a comparatively broad dark band which probably indicates the presence of a midrib, a feature not seen in the other specimens.

III.—CONCLUSION.

The following species have been recorded as representatives of the Stormberg Flora :—

Equisetales.

Schizoneura krasseri sp. nov.	S.W. of Matatiele, Griqualand E., Tina River.
Strobilites sp.....	Tina River.

Filicales.

Thinnfeldia odontopteroides (Morr.)	Kenigha River, W. of Maclear, Griqualand E., S.W. Matatiele.
Thinnfeldia rhomboidalis Ett.....	Stormberg.
Cladophlebis sp. (Feistmantel)	Indwe.
Callipteridium stormbergense sp. nov. ..	Kenigha River.
Tæniopteris carruthersi Ten.-Woods	Kenigha River.
Chiropteris cuneata (Carr.)	Cyphergat.
Chiropteris zeilleri sp. nov.	Cyphergat.

Ginkgoales.

Baiera stormbergensis sp. nov.	Kenigha River.
Baiera schencki Feist.	Indwe, Stormberg.

Plants of Doubtful Position.

Phœnicopsis elongatus (Morr.)	Indwe, Molteno, Stormberg, Cyphergat.
Stenopteris elongata (Carr.).....	Kenigha River.

The flora of the Stormberg series may be assigned to the Rhætic period, a period of which the vegetation has left remnants in nearly all parts of the world. In a paper on Rhætic plants from Honduras, Prof. Newberry* drew attention to the uniformity of the Rhætic vegetation both in the old and new worlds, and added: "We shall

* Newberry (88).

look now with eagerness to South America for the identification there of this Mesozoic flora, which we have found in full development in Virginia, New Mexico, Sonora, and now in Honduras. It has been recognised in Australia, New Zealand, India, Tonquin, China, Turkestan, and various parts of Europe. Hence with its discovery in South America we shall see it reaching as a girdle around the entire globe." Before this was written Geinitz had recorded Rhætic plants from the Argentine, and more recently Szajnocha, Solms-Laubach, and Kurtz have made further contributions towards the completion of this girdle of Rhætic floras.

The facts of greatest interests as regards the vegetation of this period are—the striking departure, as regards the general facies of the floras, from the type represented by the Palæozoic floras, and, secondly, its uniform character in almost all parts of the world.

Schizoneura krasseri sp. nov.—This type of Equisetaceous plant closely resembles forms recorded from Scania, Tongking, Persia, and India, but the accurate determination of fragments of vegetative stem-casts is an impossible task without the evidence of reproductive organs and the study of anatomical characters.

Thinnfeldia.—This generic type—very closely allied to *Ptilozamites* and other genera—is one of the most characteristic and widely spread Rhætic plants. It occurs in Europe (Scania, Germany, Italy, Poland, and elsewhere), Australia, South America, and India. In North America a very similar type of plant is recorded from rocks assigned to a Permian horizon.

Callipteridium stormbergense.—This type does not afford much assistance in solving the question of geological age; ferns of similar external form occur both in Permian and Liassic strata.

Tæniopteris carruthersi.—The genus *Tæniopteris* is so abundantly represented in strata ranging from Triassic to Wealden in various parts of the world that we cannot with safety base conclusions on fragments of sterile fronds, but so far as the evidence goes it favours the identification of the African form with Rhætic species from other regions.

Chiropteris.—This appears to be a comparatively rare type, but such evidence as it affords as to geological age points to a Rhætic horizon.

Baiera stormbergensis.—This unusual form of leaf appears to be a distinct species, but such Ginkgoales species as resemble it most closely are recorded from Australian strata that may probably be regarded as Rhætic.

Stachypitys.—This fragmentary fossil cannot be determined with

confidence, but it is in this case also Rhætic types with which the Stormberg plant exhibits the greatest resemblance.

Phœnicopsis.—A widely-spread form of leaf of which the systematic position is uncertain. Leaves from Europe, China, Australia, and Tongking (referred by Zeiller to *Nœggerathiopsis*) of Rhætic age and species described by Heer from Arctic Jurassic rocks exhibit a very close resemblance to the African specimens.

Stenopteris elongata.—A little-known type occurring in South America, Australia, and South Africa in beds which are probably of Rhætic age.

[Note.—Since the above was written I have received, through the kindness of Professor Zeiller, a copy of his atlas of the "Flore fossile des gîtes de Charbon du Tonkin" (Paris, 1902). Some of the plants shown in the unusually good photographic reproductions bear a close resemblance to Stormberg species. *Schizoneura carrerei* Zeill. is probably identical with the stem which I have named *S. krasseri; Ctenopteris sarreni* Zeill. probably represents a type closely allied to, but not identical with, *Thinnfeldia;* the leaves referred to *Nœggerathiopsis hislopi* may, I think, be identical with *Phœnicopsis elongata.*]

III.—*ECCA FLORA.*

Plates X.–XIII.

Text-figure 8.

I.—INTRODUCTION.

The base of the Lower Karoo formation has been described as consisting in certain regions of a conglomerate to which Dunn's term, Dwyka conglomerate, has frequently been applied. The history of our knowledge of this member of the Karoo formation has recently been dealt with in the Annual Report of the Geological Commission of Cape Colony for 1900.* In recent years attention has been given to the occurrence of conglomerates in the Transvaal which are correlated with the Dwyka conglomerate of Cape Colony and Natal. In 1895 Schmeisser recorded *Schizoneura* and *Glossopteris* from Transvaal collieries in beds resting on the conglomerates, and concluded that the plant-bearing strata should be correlated with Ecca shales of Cape Colony. Dr. Corstorphine in his Report of 1900 † summarises the observations bearing on the nature and age of the conglomerates of Cape Colony and the Transvaal as follows: "The evidence of the glacial action in the Dwyka conglomerates has accumulated to such an extent during recent years that doubt can no longer remain that the rock owes its peculiarities to such action, and that the Transvaal conglomerates, associated with the coal, are also unmistakably of glacial origin, and, from the fossil evidence found in the overlying rocks, can equally surely be regarded as being at the same geological horizon as the Southern Dwyka."

In 1896 Professor Zeiller ‡ published an important paper in the Bulletin of the Geological Society of France dealing with fossil plants obtained from the neighbourhood of Johannesburg. These included *Glossopteris* (leaves and rhizome), a species of *Sphenopteris*, *Phyllotheca*, *Nœggerathiopsis hislopi* (Bunb.), and some seeds. In the following year Mr. David Draper § read a paper before the Geological Society of London, in which he referred to certain plants obtained from a quarry 2 miles east of Vereeniging, a township 30 miles south of Johannesburg. He expressed the opinion that

* Corstorphine (00).

† Corstorphine (00), p. 17.

‡ Zeiller (96).

§ Draper (97).

the plant-bearing strata should be assigned to a Triassic horizon. Through the courtesy of Mr. Draper, I had the opportunity of describing the Vereeniging plants,* which were referred to the following genera: *Glossopteris, Gangamopteris, Nœggerathiopsis,* and *Sigillaria*—types unmistakably indicating a Permo-Carboniferous age. In 1898 Dr. Hatch † gave an account of the Geology of certain districts in the Southern Transvaal, and in an appendix to his paper I added a short description of a few plant remains from the Vereeniging Sandstone.‡ A Geological map of the Vereeniging district is published in Dr. Hatch's memoir, and sections are also given by Mr. Draper in his paper of 1897.

The plants from Vereeniging described in the following pages were obtained by Mr. Leslie from the bed of the Vaal River, about 3 miles from the locality where Mr. Draper's specimens were collected. An expression of thanks is due to Mr. Leslie for the important additions to the Palæozoic Flora of South Africa which we owe to his enthusiasm and ability.

In addition to these Lower Karoo plants from Vereeniging the collection recently submitted to me includes a few very imperfect fragments of leaves from Worcester and Tuin Kraal, a few miles south of Prince Albert Road Station, obtained from beds assigned to the Ecca series. The Ecca beds occur mainly in the Karoo, but there is a considerable outcrop also in the Breede River Valley, which has recently been examined by Mr. Schwarz,§ who mentions the occurrence of *Gangamopteris* impressions in a quarry near Worcester Station. As a matter of convenience the Worcester fossils and those from Vereeniging may be dealt with separately.

A.—ECCA PLANTS FROM WORCESTER.

Feistmantel's list of plants from the Ecca series includes the following species :— ||

Glossopteris browniana Brongn.
Gangamopteris cyclopteroides var. *attenuata* Feist.
Nœggerathiopsis hislopi (Bunb.).

The material in my hands is too meagre and imperfect to lead to any definite conclusion as to the age of the rocks; it consists of

* Seward (97). † Hatch (98). ‡ Seward (98).
§ Schwarz (98), p. 24. || Feistmantel (89).

small and fragmentary impressions of *Glossopteris* fronds, with one or two imperfect specimens of *Gangamopteris*, preserved in a mottled purple and greyish-green argillaceous rock, from Worcester, also some indistinct portions of an Equisetaceous plant. In addition to these, the rock from Tuin Kraal River contains fragments of Equisetaceous stems, probably referable to the genus *Schizoneura*.

II.—DESCRIPTION OF SPECIMENS.

Genus GLOSSOPTERIS Brongniart.

Glossopteris sp.

(Probably *Glossopteris browniana* Brongn. var. *indica*.)

Plate XIII., fig. 1.

The fragments from Worcester are too imperfect to determine with certainty. While they exhibit a fairly close agreement with Feistmantel's figure of a Beaufort specimen, *Glossopteris damudica* var. *stenonœura*,* they agree even more nearly with the large *Glossopteris* fronds, of which Zeiller has recently published some excellent photographs under the name *Glossopteris indica* Schimp.† This species Zeiller considers should not be regarded as identical with *Glossopteris browniana*. The African material is too meagre to throw any fresh light on this difficult question of specific limitation, but I have elsewhere adopted the plan of maintaining Brongniart's name, *Glossopteris browniana* var. *indica*, in preference to Schimper's specific designation, *G. indica*.‡ On the whole, I consider the Worcester specimens identical with the type of frond figured by Zeiller as *G. indica*, and by myself as *G. browniana* var. *indica*.

Plate XIII., fig. 1 (Z).

A small piece of a leaf showing clearly defined secondary veins.

Other specimens: C. A piece of a frond at least 6 cm. broad, showing a strong midrib giving off numerous oblique anastomosing veins; X, 212a, 213a, 215a; 220a, part of a large frond showing the midrib and anastomosing secondary veins; 221a.

* Feistmantel (89), pl. iv., fig. 7.

† Zeiller (02); Zeiller (96), pl. 367.

‡ Seward (97).

Genus GANGAMOPTERIS McCoy.

Gangamopteris cyclopteroides (?) Feist.

One small and very obscure fragment (specimen Y) from Worcester is no doubt a fragment of *Gangamopteris;* it agrees closely with Feistmantel's figure of *G. cyclopteroides* var. *attenuata* from the Kimberley series,* but the specimen is too poor to determine.

Genus SCHIZONEURA Schimper and Mougeot.

Schizoneura sp. (?)

A single specimen (338) from Worcester consists of small and very obscure impressions of what are probably pieces of a *Schizoneura* stem, also a fragment of an Equisetaceous stem (351) on a piece of sandstone from a kopje 5 miles north of Worcester.

Three other specimens (104a, 110a, 111a) from the Tuin Kraal River agree in the crowded internodal ribs with the Stormberg examples shown in figs. 5, 6, pl. ix., but they may also be closely matched with specimens of *Schizoneura gondwanesis* Feist. from India, and with impressions from more than one geological horizon.

The available evidence is insufficient to throw much light on the age of the Worcester and Tuin Kraal rocks, but it is not unfavourable to the view that the beds in question are correctly placed on the horizon of the Ecca series.

B.—ECCA PLANTS FROM VEREENIGING. †

The specimens recently collected in the Vereeniging sandstones by Mr. Leslie are of especial interest as including three generic types, *Psygmophyllum*, *Neuropteridium*, and a Lepidodendroid stem hitherto unknown from South Africa. The genus *Neuropteridium* is important as an additional link between the Lower Gondwana floras of India and South America on the one hand, and the South African flora on the other. The genera *Psygmophyllum* and *Bothrodendron* suggest interesting comparisons, from the point of view of geological distribution, between South African and European Palæozoic floras.

* Feistmantel (89), pl. iv., fig. 2.

† These plants are described here for comparison with the plants of the same age found within the limits of Cape Colony.

FILICALES.

There can be little doubt that the genus *Glossopteris* should be included in the Filicales. It is true we have not yet found fertile specimens showing recognisable sporangia, but in addition to the evidence furnished by the fern-like character of the sterile leaves, the rhizome (*Vertebraria*) * exhibits features characteristic of ferns. As regards *Gangamopteris*, which differs in no important respect from *Glossopteris*, we may reasonably accept the view that it is also a member of the Filicineæ.

Genus GLOSSOPTERIS Brongniart.

Glossopteris browniana Brongn. var. indica.

Plate X., figs. 3, 4.

1828. *Glossopteris Browniana* Brongniart, Prodrome, p. 54.
G. Browniana var. *indica* Brongniart, Hist. vég. foss., p. 223, pl. lxii., fig. 2.
1869. *Glossopteris indica* Schimper, Trait. pal. vég., vol. i., p. 645.
1896. *G. indica* Zeiller, Bull. Soc. Géol. France, vol. xxiv. [3], p. 366, figs. 11, 12, 13, pl. xvii., figs. 1–3.
1898. *Glossopteris Browniana* var. *indica* Seward, Quart. Journ. Geol. Soc., vol. liv., p. 92.
1900. *G. indica* Potonié, Deutsch-Ost-afrika, vol. vii., p. 2, fig. 22.
1902. *G. indica* Zeiller, Obs. Sur. Quelques plant. foss. Lower Gond. Mem. Geol. Surv. India, p. 8, pl. i.–iii.
1902. *G. Browniana* Arber, Quart. Journ. Geol. Soc., vol. lviii., p. 5.
1902. *G. indica*, Zeiller, Flore fossile Tonkin (Atlas), pl. xvi., figs. 2–5.

The accurate identification or diagnosis of *Glossopteris* fronds, and their separation into specific types, is, I believe, a hopeless task, and I have purposely refrained from attempting a full synonomy of *Glossopteris browniana* var. *indica* (or *G. indica*).

In a recent paper on fossil plants from New South Wales, Mr. Arber † has given several references to literature in which records of Brongniart's type occur. Important contributions have in recent

* Zeiller (96), p. 351.

† Arber (02), p. 5.

years been made by Professor Zeiller, of Paris, to our knowledge of the venation characters of *Glossopteris* fronds. In his account of fossil plants from the neighbourhood of Johannesburg, Zeiller gives drawings of the venation characters of the type-specimen * of *Glossopteris indica* Schimp., and in his memoir on Indian plants † the venation characters of this and other forms are admirably illustrated. We still lack satisfactory information as to the taxonomic position of the genus, although one is tempted to draw conclusions from negative evidence.

The extraordinary abundance of *Glossopteris* fronds monopolising vast areas of sedimentary beds in different regions of India, South Africa, Australia, and elsewhere, renders the absence of well-defined and undoubted sporangia a striking fact. It may be that the fertile fronds differed considerably in form from the sterile, or possibly typical filicinean sporangia were not borne by the leaves of this genus.

The most interesting consideration in regard to *Glossopteris* is its geographical distribution. The announcement by Amalitzky ‡ in 1897 of the occurrence of this plant in Permian beds of Vologda, which has already been discussed by Zeiller in a paper published in 1898, § constituted an important contribution to our knowledge.

The *Glossopteris* leaves from Vereeniging are for the most part very imperfectly preserved, and the venation characters are not sufficiently distinct to describe in detail. In many cases the midrib is clearly shown, but the secondary veins are either invisible or exceedingly obscure.

Plate X., fig. 4 (XXII.).

A broader form of leaf, 21 cm. long, agreeing in shape with specimens of the type known as *Glossopteris browniana* var. *indica*. The midrib is distinctly shown, but hardly any trace of secondary veins can be detected.

GLOSSOPTERIS BROWNIANA Brongn. var. ANGUSTIFOLIA.

Plate X., fig. 3.

I have previously adopted this designation for the narrow type of *Glossopteris* fronds which Brongniart named *G. angustifolia*. The specimens from Vereeniging are too imperfect to afford any guide as to the advisability of regarding the narrower leaves as a distinct

* Zeiller (96), p. 367, figs. 11, 12.
‡ Amalitzky (97).
† *Ibid.* (02).
§ Zeiller (98).

species or including them under the comprehensive title *Glossopteris browniana*.

Narrow *Glossopteris* leaves were found in the Vereeniging rocks in association with *Sigillaria*, and described in 1897.*

Plate X., fig. 3 (XXII.).

This specimen, 20 cm. long, represents the long and narrower type of frond comparable with *Glossopteris angustifolia* Brongn., but the venation is too obscure to be represented in detail in the drawing; the parallel lines in the figure are merely shading, but the darker band in the middle of the frond indicates the presence of a distinct midrib.

Other specimens: Imperfect *Glossopteris* fronds are seen in specimens 1, 2, 3, xx., xxi., xxiv., xxv.

Genus GANGAMOPTERIS, McCoy.

Gangamopteris cyclopteroides, Feist.

Plate XIII., fig. 5.

1869. *Nœggerathia obovata*, Carruthers, Geol. Mag., vol. vi., p. 9, pl. vi.
1876. *Gangamopteris cyclopteroides*, Feistmantel, Rec. Geol. Surv. India, vol. ix., pt. iii., p. 73.
1879. *Gangamopteris cyclopteroides*, Feistmantel, Foss. Flor. Gond. System, vol. iii., p. 12, pl. vii., ix.–xiii., xxvi., xxvii.
1899. *Gangamopteris cyclopteroides*, Feistmantel, Abh. k. böhm. Ges. Wiss., p. 37, pl. iv., fig. 2.
1890. *Gangamopteris cyclopteroides*, Feistmantel, Mem. Geol. Surv. New South Wales, Palæont., No. 3, p. 131.
1894. *Gangamopteris cyclopteroides*, Kurtz, Revist. Mus. de la Plata, p. 13, pl. ii.
1895. *Gangamopteris cyclopteroides*, Zeiller, Bull. Soc. Géol. France, vol. xxiii. [3], pl. x.
1896. *Gangamopteris cyclopteroides*, Bodenbender, Zeit. deutsch. geol. Ges., vol. xlviii., p. 772.
1897. *Gangamopteris cyclopteroides*, Seward, Quart. Journ. Geol. Soc., vol. liii., p. 323, pl. xxii., fig. 1, text-figure 1, C. 324.
1898. *Gangamopteris cyclopteroides*, Seward, Quart. Journ. Geol. Soc., vol. liv., p. 92.

* Seward (97), p. 321, pl. xxi., fig. 4*a*.

An inspection of the type-specimen of Carruthers' Brazilian leaf,* which he referred to *Nœggerathia*, convinces me that it should be placed in Feistmantel's species *Gangamopteris cyclopteroides;* the numerous and slightly spreading veins are undoubtedly connected here and there by oblique anastomoses as in the typical Indian leaves.

The association in Brazil of *Neuropteridium validum* (= *Odontopteris plantiana* Carr.) and *Gangamopteris*† (= *Nœggerathia obovata* Carr.) is an interesting fact in view of the same association recorded by Kurtz in the Argentine, and now known to occur in South Africa. The specimens of *Gangamopteris* included in the recently acquired collection from Vereeniging are inferior in preservation to the leaf that I previously figured from the same locality (British Museum Collection, V. 3615).

Plate XIII., fig. 5 (A).

Part of a leaf showing numerous oblique and occasionally anastomosing veins converging towards a central depression, where they follow an approximately vertical course. The well-marked median groove gives an exaggerated impression of a midrib, which in reality is by no means as distinct as it is in a *Glossopteris* frond.

FILICALES OR CYCADOFILICES?

The genus *Neuropteridium* has been as a matter of course assigned to the ferns, but we must recognise the fact that the Indian and Southern Hemisphere fronds have not as yet been found in a fertile condition. Another point of importance is the resemblance as regards vegetative characters between this genus and *Neuropteris*, a fact which suggests the possibility that *Neuropteridium*, like *Neuropteris* and *Alethopteris*, may have been a plant in which cycadean and filicinean characters were combined.

Genus NEUROPTERIDIUM, Schimper.

Schimper suggested the name *Neuropteridium* as a subgenus of *Neuropteris* in 1869 ‡ for a type of frond from the Bunter of the

* Carruthers (69), pl. vi., fig. 1.

† See also Zeiller (95), pl. x.

‡ Schimper (69), p. 447: Schimper and Mougeot (44), pl. xxxvi.

Vosges, which he named *Neuropteridium grandifolia;* he defined the subgenus as follows:—

"Frons simpliciter pinnata, pinnis integerrinis basi coarctatis, infra mediam basim insertis; nervo medio plus minusve distincto."

The long pinnate fronds of the type-species bore segments 4–5 cm. in length and 2 cm. broad; they differ in no essential features from the leaf represented in pl. x., fig. 1.

In 1879 Feistmantel * published several drawings of large fronds from Lower Gondwana rocks of India, which he at first designated *Neuropteris valida*, but afterwards † *Neuropteridium validum*. These Indian specimens, as Feistmantel pointed out, bear a close resemblance to the Triassic European species described by Schimper and Mougeot.‡ The only evidence at present available, so far as I am aware, in regard to the nature of the reproductive organs of fronds included in *Neuropteridium* is that afforded by specimens from the Bunter rocks of the Vosges described by Schimper and Mougeot under the name *Crematopteris*. Zeiller § considers that the fossils so named are the fertile fronds of *Neuropteridium*, and suggest a comparison with certain recent species of *Lomaria*. There is little doubt that *Crematopteris* of Schimper and Mougeot represents the fertile condition of a Triassic species of *Neuropteridium* from the Vosges sandstone—*N. imbricatum* S. and M.; but the fertile pinnules exhibit nothing more than crowded dots or pits as shown in the drawing (Schimper and Mougeot, pl. xxxv., fig. 3) without any indication of sporangial structure. Granting the correctness of Zeiller's view, and that the reproductive organs are of the nature of sporangia, we are still without information as to the nature of the fertile leaves of *Neuropteridium grandifolium*, the Triassic species which so closely resembles *N. validium*. No fertile examples have been described from the Talchir-Karbarbari beds, where the southern species is particularly abundant, and it may be that—like the northern Palæozoic genera *Alethopteris*, *Neuropteris*, and other fern-like leaves—*Neuropteridium* bore Gymnospermous rather than filicinean reproductive organs.

In dealing with genera that are regarded as characteristic members of the *Glossopteris* flora it is important to consider their possible relationship or identity with northern Palæozoic types. The genus *Neuropteridium* is usually described as a fern confined to the Lower Gondwana rocks of India and South America and to the Bunter beds of the Vosges in Europe. We are now able to extend the range to

* Feistmantel (79, 79[a]), p. 10.

† *Ibid.* (81), p. 53.

‡ Schimper and Mougeot (44).

§ Zeiller (00), p. 109.

South Africa. There are, however, a few Northern Hemisphere forms characteristic of Lower Carboniferous strata which exhibit a very close agreement with *Neuropteridium*. The well-known *Cardiopteris frondosa* (Goepp.) from the Culm of Germany, as figured by Stur,* Schimper,† and others is characterised by large pinnate fronds bearing semicircular entire segments in the lower part of the leaf and longer and slightly lobed pinnules in the upper portion of the frond, as in the African specimen represented in pl. x., fig. 1.

A portion of a pinnate frond almost identical with that shown on pl. x. is figured by Fritsch from Thuringian Culm rocks as *Archæopteris dawsoni* Stur.‡ A plant recently described by Grigoriew from Upper Carboniferous rocks of Russia as *Neuropteris* cf. *cordata* Brongn. var. *densineura* is also very similar to the African frond, and should hardly be referred to a distinct genus.§ It is probably better, at least more convenient, to retain the two names *Cardiopteris* and *Neuropteridium;* but in some cases we must admit either designation might be used with equal propriety as regards external characters of the frond, irrespective of geographical distribution. *Cardiopteris* as at present used denotes fronds usually of Lower Carboniferous age characterised by pinnules that tend to be more orbicular and less deeply lobed than those of *Neuropteridium;* the latter genus, moreover, with the exception of the Vosges species, forms an element of the southern *Glossopteris* flora, while the former is northern in its range.

Neuropteridium validum Feist.

Plate X., fig. 1.

1869. *Odontopteris Plantiana* Carruthers, Geol. Mag., vol. vi., p. 9, pl. vi., figs. 2, 3.
1878. *Neuropteris valida* Feistmantel, Mem. Geol. Surv. India, Foss. Flor. Gondwana System, vol. iii., p. 10, pl. ii.–vi.
1880. *Neuropteridium validum* Feistmantel, *ibid.* (1880), p. 84.
1894. *Neuropteridium validum* Kurtz, Revista del Mus. de la Plata, vol. vi., p. 11, pl. 1.
1896. *Neuropteridium validum* Bodenbender, Zeit. Deutsch. Geol. Ges., vol. xlviii., p. 772.

* Stur (75), p. 41, pl. xiii., xiv.

† Schimper (69), p. 453, pl. xxxv.; also Schlumberger and Schimper (62) pl. xxv., p. 339.

‡ Fritsch (97), pl. i., fig. 3, p. 90.

§ Grigoriew (98), pl. iv.

Frond long and linear, pinnate, rachis strong, bearing pinnules which in the lower part of the frond are entire and more or less semicircular in form, and gradually pass into longer and lobed segments as we ascend the rachis. The longer pinnules, which may reach a length of 6 cm. or more, are not attached by the whole of the base, like the stouter and broader segments in the basal portion of the frond, but the basal lobe of the upper edge of the segment is free from the rachis. Apex of pinnules bluntly rounded. Veins spreading, curving towards the edge of the pinnules with repeated dichotomous branching, and converging in the longer segments to form a fairly distinct midrib in the lower part of the lamina.

The discovery of *Neuropteridium* at Vereeniging by Mr. Leslie, to which allusion has been made in a recently published article,* affords a very interesting confirmation of the striking similarity between the vegetation of the Talchir-Karharberi series of India and that of South America and South Africa. There can be no reasonable doubt as to the identity of the Indian species and the plant from Vereeniging. Similarly Carruthers' *Odontopteris plantiana* from Rio Grande do Sul, Brazil, is undoubtedly the same type, and Kurtz has already recognised the identity of Argentine specimens with Feistmantel's species. The type-specimens of Carruthers' plant from Brazil are in the British Museum Collection, and an examination of them confirms my opinion as to the identity of the Brazilian, African, and Indian fronds.

Plate X., figs. 1, 1*a*, 1*b* (XXII.).

Fig. 1 is drawn slightly less than natural size. Frond 54 cm. long. The basal portion is probably close to the actual termination, but the apex has not been preserved. The lowest pinnule, which is almost orbicular in outline, is approximately 2·5 cm. in breadth and 2 cm. in length ; the spreading and forked veins are faintly indicated. The fourth segment from the bottom of the rachis is 2·6 cm. long and 2·9 cm. broad, the margin appears to be entire, but the upper edge is flatter than the more strongly arched lower margin. The next pinnule is slightly larger, and shows the beginning of a subdivision of the lamina into broad lobes. Pinnule number 7 reaches a length of 5 cm., and has well-marked lobes with the *Neuropteris* type of venation. This segment is shown very slightly larger than

* Seward (02).

natural size in fig. 1*a*. The ninth pinnule is 6 cm. long; pinnule number 13 is shown approximately natural size in fig. 1*b*. Towards the apical margin of the frond the segments gradually decrease in size, precisely as in the Indian examples described by Feistmantel.

Plate X., fig. 2 (XXVI.).

A piece of the rachis near the base of a frond showing semicircular and orbicular segments. The veins are not seen. Associated with *Glossopteris* fronds.

LYCOPODIALES.

Genus (?) BOTHRODENDRON Lindley and Hutton.

Bothrodendron leslii sp. nov.

Plate XI., figs. 1, 1*a*, 1*b*, 4, 5, 6.

One of the most striking differences between the Upper Carboniferous and Lower Permian vegetation of the Northern Hemisphere on the one hand, and the Indian and Southern Hemisphere *Glossopteris* flora on the other, is the absence in the latter of many of the most abundant and characteristic northern genera such as *Calamites*, *Lepidodendron*, *Sigillaria*, and others. In recent years, however, instances have been recorded of the admixture of northern Palæozoic types with members of the *Glossopteris* flora: this is notably the case in South America and South Africa. Prior to the appearance of the *Glossopteris* flora in Australia there existed in that continent,* as in South America,† certain species of plants closely resembling European types—a fact pointing to a greater uniformity in the vegetation of extreme northern and southern latitudes during the Lower Carboniferous period than prevailed at a later stage. Lower Carboniferous plants have been recorded by Carruthers,‡ Feistmantel,§ Etheridge,‖ and others from Australia, which exhibit a more or less close agreement with certain species in the Northern Hemisphere. Such genera as *Rhacopteris*, *Bothrodendron*, and *Lepidodendron* afford instances of a close correspondence between the extreme northern flora of the Arctic regions and that which existed in the far south.

* Feistmantel (90).
† Kurtz (94). See also Zeiller (97).
‡ Carruthers (72).
§ Feistmantel (90).
‖ Etheridge (90) (90²); Jack and Etheridge (92).

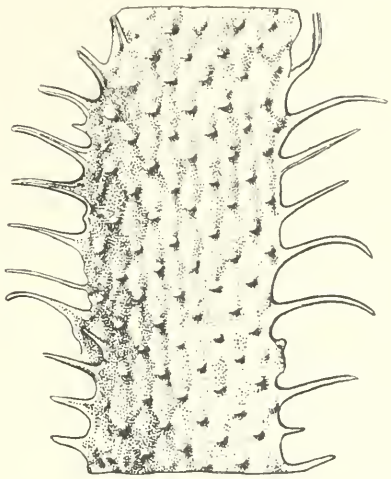
From South America Lower Carboniferous plants are recorded by Szajnocha * and Kurtz,† which, like those from Australia, point to the almost world-wide occurrence of a vegetation of uniform facies.

It has often been stated that such European types as *Calamites*, *Lepidodendron*, and others, also occur in South Africa, but apart from the recently recorded instances of the association of *Sigillaria* with *Glossopteris*, &c., it appears to be the case that the statement quoted by one author from another is based in part on incorrect determination, and largely on a confusion of localities, English or American Coal-Measure fossils having been erroneously assigned to a South African locality. In 1871 Grey ‡ referred to the occurrence of *Lepidodendron* and *Sigillaria* in the Stormberg district, but Professor Rupert Jones § expressed his belief that the plants in question were either American or English. I have no doubt, as Rupert Jones pointed out, that Grey's specimens were not originally obtained from Africa; this belief is founded on an examination of several specimens in the British Museum (V. 235, V. 2390, V. 3267), *e.g.*, *Calamites*, *Calamocladus*, *Lepidodendron*, and others, said to have been obtained from Stormberg beds.

We may next consider what authentic evidence is available bearing on the occurrence of Lepidodendroid plants in South African rocks. A few years ago Mr. David Draper, of Johannesburg, forwarded a collection of plants to me from several localities in the Transvaal. Among them were several specimens from Vereeniging, which I described || as *Sigillaria brardi* Brongn., a species characteristic of a high horizon in the North Hemisphere Coal-Measures, and met with also in Permian rocks. This *Sigillaria* was found in association with *Glossopteris*, *Gangamopteris*, and *Nœggerathiopsis*, in strata assigned to a Permo-Carboniferous age. Before dealing with the recently discovered plant represented in pl. xi., reference may be made to a few specimens in the British Museum which afford additional illustrations of South African Lycopodiaceous plants. The fossil represented in text-figure 8 (V. 236) was obtained from a locality spoken of as Atherstone Quarry, Kowie. It consists of a piece of flattened stem, 8 cm. long and 2·5 cm. broad, bearing spirally disposed circular protuberances and curved linear appendages, presumably leaves, of which some are shown in attachment to the edge of the impression. The preservation is not sufficiently

* Szajnocha (91). † Kurtz (94). ‡ Grey (71).
§ Jones (84). || Seward (97).

good to allow of specific determination, but there can be little doubt that the fragment belonged to a Lepidodendroid plant.



Text-figure 8.

Lepidodendroid stem. (Nat. size.)
From a specimen in the British Museum (V. 236).

A few other fragments in the Museum Collection (V. 2424) are stated to have been obtained from a locality near Port Alfred, Kowie mouth.

An obscure specimen (V. 2423), which may represent a fragment of a Lepidodendroid plant (? *Bothrodendron*), was found in a boulder from the Prince Albert Range, possibly from the Witteberg. The Museum Collection also includes similar fragments from Lower Albany (V. 240), which may be of Devonian age.* In addition to these fragments there are two imperfectly preserved sandstone casts obtained by Mr. Draper from Zwartkoppies, Vredefort, in the Orange River Colony, which are no doubt partially decorticated stems of some Lepidodendroid plant.

It is possible that the specimen represented in text-figure 8 and that from the Prince Albert Range may be of Devonian age. In this connection it may be mentioned that a small specimen from Witteberg included in the collection recently sent to me (No. 53a) is in all probability a fragment of a Lepidodendroid stem.

* An example of a Lepidodendroid plant is referred to by Mr. Draper in his paper of 1897, p. 313.

The specimen represented in pl. xi., fig. 1, does not show the surface features of the plant sufficiently clearly to enable one to determine its affinity with certainty; it is, I believe, a Lepidodendroid species, but we have no satisfactory indication of the nature of the appendages borne on the spirally disposed scars. In all probability, however, the appendages were leaves, and the fossils present the appearance of aerial rather than subterranean organs.

My friend Professor Zeiller has drawn my attention to some fragments figured by Feistmantel * in his memoir on the Damuda and Panchet beds of India, referred to as pieces of the stem of a coniferous plant, probably *Rhipidopsis*, which bear a resemblance to the Vereeniging fossils. We may also suggest a comparison with a specimen figured by Schmalhausen from Petschora as a piece of the stem of *Rhipidopsis ginkgoides*.† Feistmantel's specimens are too indistinct to determine, and there is no satisfactory evidence in support of his determination. The Petschora fossil seems to agree more closely with the Vereeniging stems, and may be Lepidodendroid. I am indebted to Professor Zeiller for suggesting that the fossils represented on pl. xi., figs. 1, 4, 5, 6, may be gymnospermous stems, their scars being very similar to the leaf-scars of the branches of recent species of *Abies*. It must be admitted that the surface features of the African specimens do not conform in detail to those of *Bothrodendron*, but in all probability we have to deal with partially decorticated stems, which would not exhibit the parichnos scars nor the characteristic sculpturing of the bark. The apparently dichotomous branching shown in fig. 4 is, I think, an additional argument in favour of assigning the specimens to the Lycopodiales.

In his recent and very important memoir on Upper Devonian plants of Bear Island, Professor Nathorst figures numerous examples of a Lepidodendroid plant which he identifies as *Bothrodendron kiltorkense* (Haugh.).‡ Haughton's species, *Cyclostigma kiltorkense*,§ from the Kiltorkan beds of Ireland, was placed in the genus *Bothrodendron* by Kidston ‖ as the result of an examination of a series of specimens in the Dublin Museum. Some of these Arctic specimens bear so close a resemblance to the South African plant that one might be almost tempted to regard the two as identical species. My friend Professor Nathorst, to whom I forwarded a drawing of the African stems agrees with me that they may belong

* Feistmantel (81[2]), pl. xlvii.*a*, figs. 5–7.
† Schmalhausen (79), pl. viii., fig. 12.
‡ Nathorst (02), p. 31, pl. x.–xiv.
§ Haughton (60). ‖ Kidston (89), p. 66.

to a species of *Bothrodendron*, but considers them specifically distinct from *B. kiltorkense*. The small forked specimen shown in fig. 4 may be matched almost exactly with Nathorst's figs. 1, 2, 5, 6, 10, and 11 in pl. xi. of the Bear Island Memoir. The larger and more perfect specimen from Vereeniging (pl. xi., fig. 1) also agrees closely with some of Nathorst's examples. In spite of the close superficial agreement, I believe the African plant to be a distinct species—a view which my friend Mr. Kidston also unhesitatingly adopts. In the stems from South Africa I am unable to detect any trace of the two lateral scars, representing the parichnos, shown in some of Nathorst's figures of the leaf-scars of *Bothrodendron kiltorkense;* the absence of the parichnos scars may be due to the partial decortication of the stems. Another plant which may be compared with the African species is *Cyclostigma australe*, as figured by Feistmantel* from Devonian rocks of New South Wales. This Australian type is possibly identical with Haughton's species. The variation in the arrangement of the scars is in accordance with a reference of the fossils to the Lycopodiales; striking examples of *Sigillaria* with leaf-scars closely approximated in certain regions of the stem, and farther apart in other regions, have been figured by Kidston, Zeiller, and other authors.

The Vereeniging plant appears to agree as regards the size, form and arrangement of the scars with the genus *Bothrodendron* (including under this term *Cyclostigma*) more closely than with other members of the Lycopodiales. I purpose to designate the specimens *Bothrodendron leslii*.

Plate XI., figs. 1, 1*a*, 1*b* (XXI.).

A piece of a stem, 29 cm. long, and varying in breadth from 1·5 to 2 cm. The small piece at the upper end—as shown in the drawing—is at a higher level than the rest, and shows the almost circular scars as prominences with a central depression. Below this the scars occur as depressions with a central umbo, and in some of them one is able to detect a small pit in the centre of the umbo (1*a*), the pit no doubt marking the position of the vascular bundle, which supplied the spirally disposed appendages. In all probability the uppermost piece of the specimen is the impression of the outer, but partially decorticated, surface of the organ, while the remainder of the specimen represents the inner face of the compressed cortex, the internal tissues—wood and pith—having been removed. At *c* the

* Feistmantel (90), pl. xi.

scars become more crowded and the surface shows signs of wrinkling—no doubt the result of contraction on drying. Lower down the scars again become more scattered, and later, *b*, the more crowded disposition recurs. The enlarged drawing of the region *b* (1*b*) shows more clearly the nature of the scars and their arrangement : in many of them the preservation is not sufficiently good to show the vascular bundle pit in the central umbo. Below the region *b* the surface features become more obscure.

Plate XI., fig. 4 (B).

This fragment is of interest as showing the dichotomous branching ; the scars are precisely like those of the larger specimen, but their preservation is less perfect.

Plate XI., fig. 5 (XX.).

An obscurely preserved and wrinkled specimen, similar to xxi. (fig. 1).

Plate XI., fig. 6 (XX.).

A larger branched fragment, bearing scars like those of xxi. (fig. 1), but showing the surface features much less clearly. There are indications here and there of impressions suggesting narrow linear, leaf-like appendages lying on the stem, but the preservation is too poor to enable one to recognise any certain traces of appendages.

? GINKGOALES.

Genus PSYGMOPHYLLUM Schimper.

This genus was instituted by Schimper in 1870 * for leaves of Permian and Upper Carboniferous age previously referred to *Nœggerathia*. He defined it as follows :—

" Folia pinnatisecta, pinnis erecto patentibus, e basi valde angustata flabelliformibus, longitudinaliter flabellatim plicatis, plus minus profunde pinnatisectis, vel margine lobatis sen crenatis ; nervis plusies dichotomis, erecto-radiantibus. Vernatio foliorum verticaliter involuta."

Psygmophyllum is placed by Schimper among the Cycads, while later authors † have preferred to regard the lobed and wedge-shaped

* Schimper (70), p. 192. † Saporta (84), p. 230 ; Zeiller (00), p. 251.

leaves as probably those of a member of the Ginkgoales. We have, however, no evidence beyond such as is afforded by the not very close resemblance of the leaves to those of *Ginkgo* that can be accepted as in any way deciding the position of Schimper's genus.*

The genus *Ginkgophyllum* was adopted by Renault and Saporta † for leaves which cannot be distinguished from *Psygmophyllum*, but I see no reason for substituting the more committal term for Schimper's older designation. Feistmantel's *Euryphyllum whittianum* ‡ from the Karharbari Coal-field may be compared with *Psygmophyllum* as regards the tapered base of the leaves and their arrangement on the stem, but the *Ginkgo*-like form of the bilobed lamina affords a distinctive feature of the latter genus.

Psygmophyllum kidstoni, sp. nov.

Plate XII., fig. 1.

Vegetative shoots woody, bearing spirally disposed leaves. Leaves wedge-shaped, reaching a length of 13 cm., usually divided by a deep median sinus into two narrow wedge-shaped lobes, truncate distally and tapering gradually to the proximal end of the lamina. Leaves sessile, attached to the axis by a narrow base. The lamina is traversed by numerous spreading and occasionally forked veins following a course parallel to the edge of the leaf.

Organs of reproduction unknown.

Leaves of the *Psygmophyllum* type have hitherto been recorded from the following regions and geological horizons:—

Psygmophyllum flabellatum (L. and H.),§ Coal-Measures of Newcastle-upon-Tyne, England.

Psygmophyllum williamsoni, Nath,‖ Culm beds of Spitzbergen.

Ginkgophyllum flabellatum (L. and H.), Renault, Cours. Bot. Foss. 1881, p. 65, pl. vii., fig. 5.

Psygmophyllum expansum (Brongn.),¶ Permian of Russia.

Psygmophyllum grasseti (Sap.),** Permian of Lodève.

Ginkgophyllum minus, Sandb.†† Coal-Measures or Permain of the Black Forest.

* Seward and Gowan (00), p. 136.

† Renault (81), p. 65; Saporta (84), p. 230.

‡ Feistmantel (79), pl. xxi. § Lindley and Hutton (32), pl. xxviii., xxix.

‖ Nathorst (94), pl. ii., figs. 1, 2.

¶ Murchison (45), vol. ii., p. 9, pl. E. See also d'Eichwald (55), pl. xiii., fig. 17, and Schmalhausen (87), p. 18, pl. iii., iv.

** Saporta (84), p. 228, pl. cli., fig. 2. †† Sandberger (90), p. 101.

Two specimens of *Psygmophyllum flabellatum* in the British Museum from the Coal-Measures of Newcastle (England) bear so close a resemblance to the South African plant that I am unable to detect any well-marked differences. One of these specimens (40578) is a large leaf tapering gradually to a narrow basal region with a lamina 15 cm. long and 11·5 cm. broad, agreeing in size and shape with the example shown in pl. xiii. The other specimen (38927) shows an axis like that represented in pl. xiii. bearing portions of two long wedge-shaped leaves. The collection includes a similar specimen, but less clearly preserved, from the Province of Perm, in Russia, referred to *Psygmophyllum expansum* Brongn.,* a type which is probably closely related to the species of Lindley and Hutton.† Nathorst's ‡ *Psygmophyllum williamsoni* from Spitzbergen bears a resemblance to *P. kidstoni*, and is of interest as coming from a lower horizon than the other examples of the genus. Several fossils have been figured by Schmalhausen from the Permian of Russia under the generic name *Psygmophyllum*, and some of these undoubtedly represent species bearing a close resemblance both to *P. flabellatum* (L. and H.) of the English Coal-Measures and to the Vereeniging plant; this is the case with some at least of the specimens referred by Schmalhausen to Brongniart's species *Psygmophyllum expansum*.§ On the other hand, such forms as that represented in his fig. 11, pl. iii.—referred to *P. cuneifolium* (Brongn.)—can hardly be accepted as species of this genus. The specimen named by Schmalhausen *Baiera gigas* ‖ is in all probability a leaf of *Psygmophyllum*, and may indeed be identical with the African plant.

The leaves from Russia described by Schmalhausen as *Rhipidopsis ginkoides* ¶ differ from those of the African plant in being compound, but the individual leaflets are very similar to the leaves represented in pl. xiii. Under the name *Archæopteris archetypus* the same author has figured leaves from Upper Devonian age in Russia ** which may be compared with *Psygmophyllum kidstoni*; the habit of the branch as shown in one of Schmalhausen's figures (pl. ii.) appears to be identical with that of the African plant. *Nœggerathia foliosa* Sternb., a species characteristic of the Radnitz Coal-Measures, Bohemia, and described by Feistmantel from Silesia,†† also bears a resemblance to

* Brongniart in Murchison (45), pl. E.
† Lindley and Hutton (32), pl. xxviii.–xxix.
‡ Nathorst (94), pl. ii., figs. 1, 2.
§ Schmalhausen (87), pl. iii., fig. 10; pl. iv., figs. 1–6.
‖ *Op. cit.*, pl. v., fig. 10.
¶ Schmalhausen (79), pl. vi.
** *Ibid.* (91), p. 23, pl. ii.
†† Feistmantel (75), pl. v., fig. 1.

the Vereeniging plant as regards the form, venation, and manner of attachment of the leaves. As an example of a plant from a higher geological horizon not unlike the African type, reference may be made to *Nœggerathia vogesiaca* Bronn from the Raibl Rhætic beds, but Bronn's plant has a broader axis, and the longer leaves are disposed in two rows like the pinnæ of a Cycadean frond.*

Plate XII., fig. 1 (XXIII.).

The woody and fairly stout axis reaches a length of 34 cm., the leaves appear to be arranged spirally, and in some of them the attachment to the axis is clearly shown. The venation is faintly indicated, but sufficiently obvious to show that the lamina is traversed by numerous veins following a course approximately parallel to the edges of the leaf. The leaf *a*, which is incomplete, and may indeed represent half the original lamina, shows the gradual tapering towards the base. Leaf *b* is still attached to the axis, and illustrates the bilobed character, the wedge-shaped lamina being divided by a deep median sinus into two halves, one of which has become pressed down to a slightly lower level in the matrix of the rock than the other. In the incomplete and lobed lamina of leaf *c* the veins are fairly distinct. A portion of leaf *d* is seen in direct continuity with the axis. The lamina of leaf *e* is almost perfect, and shows the bilobed character very clearly.

CORDAITALES.

Genus NŒGGERATHIOPSIS, Feistmantel.

Feistmantel's generic name instituted in 1879 † is another illustration of the influence of geographical distribution on nomenclature. Had the leaves referred to this genus been found in European Palæozoic rocks there can be little doubt that they would have been described under the name *Cordaites*. Professor Zeiller ‡ has drawn attention to slight differences as regards venation between the leaves of the two genera, and in fragments of cuticle detached from a South African specimen the disposition of the stomata appears to differ to some extent from that in *Cordaites*. Kurtz § in a recent note has incidentally referred to the more spreading arrangement of the veins

* Bronn (58), pl. vi.

‡ Zeiller (96), p. 23. See also Feistmantel (90).

† Feistmantel (79), p. 23.

§ Kurtz (03), p. 25.

as a distinguishing character of *Nœggerathiopsis*, but the concensus of opinion favours the view that these northern and southern leaves with parallel or slightly spreading veins belong to closely allied genera, and should both be included in the Cordaitales. In his recent memoir on Lower Gondwana plants Zeiller * expresses himself strongly in favour of regarding *Nœggerathiopsis hislopi* (Bunb.) as a species of the Cordaiteæ, and very closely allied to *Cordaites*. Solms-Laubach,† Krasser,‡ Arber,§ and other authors adopt a similar view.

The leaves of Heer's genus *Phœnicopsis*, which I believe to be identical with *Zeugophyllites*, differ from the broader leaves of *Nœggerathiopsis* in the absence of the frequent dichotomous branching of the veins. As Zeiller says, we cannot resist the inference that the Gymnospermous seeds found in association with *Nœggerathiopsis* in the Karharbari beds may, like the European *Cardiocarpus* seeds in association with *Cordaites*, have been borne by this southern member of the Cordaiteæ.‖ The leaf from Tonking named by Zeiller ¶ *Nœggerathiopsis hislopi* bears so close a resemblance to the Stormberg plant *Phœnicopsis elongata* that I am inclined to think the latter generic name more appropriate than *Nœggerathiopsis*.

Nœggerathiopsis hislopi (Bunb.).

Plate X., fig. 5; Plate. XIII., figs. 2–4.

1861. *Nœggerathia Hislopi*, Bunbury, Quart. Journ. Geol. Soc., vol. xvii., p. 334, pl. x., fig. 5.

1879. *Nœggerathiopsis Hislopi*, Feistmantel, Foss. Flor. Gondwana System, vol. iii., p. 23, pls. xix., xx., xxviii., xxix., xxx.

1879. ? *Rhiptozamites Goepperti*, Schmalhausen, Mém. Acad. imp., St. Pétersburg, vol. xxvii. [7], p. 32, pl. iv., figs. 2–4; pl. vii., figs. 23–27.

1887. *Rhiptozamites Goepperti*, Schmalhausen, Mém. Com. Géol., vol. ii., No. 4, pl. v., fig. 6.

1890. Cf. *Nœggerathiopsis spathulata* and *N. media*, Feistmantel, Mem. Geol. Surv., N.S. Wales, p. 154, pl. xxi., figs. 3–5.

1897. *Nœggerathiopsis Hislopi*, Seward, Quart. Journ. Geol. Soc., vol. liii., p. 322, pl. xxi., fig. 4*b*.

* Zeiller (02), p. 31.
‡ Krasser (00).
‖ Zeiller (02), p. 32.
† Solms-Laubach (91), p. 110.
§ Arber (02).
¶ *Ibid.* (82), pl. xii., fig. 13 (02^2), pl. xl.

1894. *Nœggerathiopsis Hislopi*, Kurtz, Revist. Mus. de la Plata, p. 15, pl. iii., figs. 3, 4; pl. iv., figs. 1–3.
1896. *Nœggerathiopsis Hislopi*, Zeiller, Bull. soc. géol. France, vol. xxiv. [3], p. 372, figs. 16, 17, and pl. xviii., figs. 6–9.
1898. *Nœggerathiopsis Hislopi*, Seward, Quart. Journ. Geol. Soc., vol. liv., p. 93.
1900. ? *Nœggerathiopsis Hislopi*, Potonié, Deutsch-Ostafrika, Bd. vii., p. 7.
1902. ? *Nœggerathiopsis Goepperti*, Arber, Quart. Journ. Geol. Soc., vol. lviii., p. 17, pl. i., figs. 1, 2.

Leaves broadly linear, varying considerably in size and shape, traversed by numerous parallel veins exhibiting dichotomous branching, more especially in the basal portion of the lamina, but occasionally also in other parts of the leaf. In the longer leaves the veins follow a straight course through the greater part of the lamina, but in the shorter and obovate leaves the veins tend to diverge towards the edges in the upper part of the lamina. The epidermal cells have rectilinear walls.

The Russian fossils originally referred by Schmalhausen* to *Rhiptozamites* from strata which are said to be of Jurassic age, but which have been more recently demonstrated by Zeiller† to be Palæozoic, are no doubt very closely allied to *Nœggerathiopsis hislopi*. *Rhiptozamites goepperti* is recorded also from Russian Permian rocks by Schmalhausen, and the leaf figured in his pl. v., fig. 6‡ can hardly be specifically distinguished from the smaller forms of *Nœggerathiopsis hislopi* from Vereeniging. Feistmantel§ and Zeiller‖ have both drawn attention to the resemblance between *Rhiptozamites* and *Cordaites*, and there can be little doubt that Schmalhausen's plant should be placed in the Cordaiteæ and regarded as generally identical with *Nœggerathiopsis* or *Cordaites*. Arber• has described imperfect leaves from Australia which, as he observes, are probably identical with the Russian type; he notes the close resemblance between Bunbury's species *N. hislopi* and *N. goepperti*, but prefers to retain both specific names.

Plate XIII., fig. 4 (XXIV.).

Part of the torn lamina of a leaf, incomplete at both ends. The leaf is traversed by slightly spreading and crowded veins which

* Schmalhausen (79).
† Zeiller (96²).
‡ Schmalhausen (87).
§ Feistmantel (90), p. 153.
‖ Zeiller (96-), p. 475.
• Arber (02), p. 17, pl. i.

occasionally bifurcate. The lamina is curved so as to present a convex surface; it extends distally into the sandstone, so that the apparently triangular apex does not represent the actual termination but merely the boundary of the exposed part of the specimen. This leaf may be compared also with *Euryphyllum*, as figured by Feistmantel from India.

Plate XIII., fig. 2 (XXI.).

Part of a leaf 12·5 cm. long and 4 cm. broad. The venation is not very clearly shown, but the specimen is of interest on account of its striking resemblance to a leaf of *Cordaites*.

Other specimens: Fragments occur on specimens xx., xxi., xxii., xxiv. One clearly preserved impression (xxi.*b*) represents a broad linear leaf like that shown in pl. xiii., fig. 2, but with a narrow basal termination.

Plate XIII., fig. 3 (XXV.) ($\frac{1}{3}$ nat. size).

A torn leaf 10 cm. long, showing the original form of the lamina. The slightly spreading veins appear to be rather farther apart than those in the specimen shown in fig. 4, but this need not necessarily indicate a specific difference, as some at least of the finer ridges in fig. 4 may represent hypodermal strands of mechanical tissue such as are known to occur in the leaves of *Cordaites*.

Plate X., fig. 5 (XX.).

Part of a leaf showing the veins more clearly. The narrow end of the fragment does not represent the actual apex, as the lamina extends further into the rock. The veins are numerous and more oblique to the margin than in the other figured specimens.

PLANT OF DOUBTFUL POSITION.

A.—Rhizome or Root.

Plate XII., fig. 2 (XX.).

This imperfect specimen, represented natural size in the drawing, may be a rhizome giving off numerous branched roots, but it is impossible to speak with confidence as to its precise nature. It is perhaps not improbable that the fossil may be part of the rhizome,

with roots, of *Glossopteris;* a comparison may be suggested with the figure of *Vertebraria* (*Glossopteris*) published by Bunbury.*

B.—Stem.

On specimen xxi. occurs a flattened impression of a woody stem 55 cm. long and 4 cm. broad, showing a well-defined pear-shaped branch-scar. In the absence of petrified woody tissue I am unable to offer any opinion worthy of expression as to the affinity of the fossil.

III.—CONCLUSION.

The plants from Worcester are unfortunately too few in number and too fragmentary to enable one to make a definite statement as to the age of the beds, but so far as the evidence goes it points to a close resemblance of the flora with that which is more abundantly represented in the plants of the Vereeniging sandstones. I shall, therefore, confine myself to the question of the age and correlation of the Vereeniging species. It has been pointed out in the section of this paper dealing with *Bothrodendron* that the supposed occurrence of European species of *Lepidodendron*, *Calamites*, and *Pecopteris* in South African rocks is in all probability erroneous.

The European Permian and Coal-Measure species *Sigillaria brardi* Brongn. is represented by satisfactory specimens obtained from the Vereeniging rocks, and we are now able to add a second example of the Lycopodiales to the list of South African plants, but there is absolutely no proof that the Northern Hemisphere Permo-Carboniferous flora existed in Africa south of the Zambesi in Portuguese East Africa.† Without attempting a complete survey of the literature dealing with South African plants, which there is good reason for assigning to a Palæozoic horizon, we may briefly consider the general facies of the vegetation of which remnants have been recorded. Leaving out of account such fragments as cannot be satisfactorily determined, we may regard the following types as a representative series of the older vegetation of the Transvaal, Cape Colony, and other districts. Numerous specimens of *Glossopteris* have recently been obtained from Zululand and in Natal this genus and other Palæozoic plants are known to occur. Potonié has also recently described a few forms from Portuguese and German East Africa, but the greater number of the plants mentioned in the following list are from the neighbourhood of Johannesburg, Vereeniging, and other localities in the Transvaal.

* Bunbury (61), pl. xi.

† Zeiller (83).

South Africa.	South America.	India.	Australia.	European Russia or Siberia.	European Triassic Species.	European Permian, or Coal-Measure Species.
Glossopteris browniana Brongn. (Under this head may be included —at least for present purposes — *G. indica* and *G. angustifolia*..	*	*	*	*		
Gangamopteris cyclopteroides Feist.	*	*	*	*		
Sphenopteris sp.					Cf. *Neuropteridium grandifolium*	
Neuropteridium validum Feist.....	*	*				
Psygmophyllum kidstoni sp. nov.						Cf. *Psygmophyllum flabellatum* (L. and H.) * (Permian and Upper Carboniferous.)
Sigillari brardi Brongn.	*Lepidodendron pedroanum* (Carr.) and *Lepidophloios laricinus* Sternb. represent the Lycopodiales in S. America.					
Bothrodendron leslii sp. nov.....						
Nœggerathiopsis hislopi (Bunb.).....	*	*	*	*		*Cordaites* sp. cf. also *Rhiptozamites* (?) cf. *R. goepperti* as figured from Franz Joseph Land, by Newton and Teall (97), pl. xli.
Conites sp.		*				Cf. European species of *Cardiocarpus*.
Cardiocarpus sp.....						
Phyllotheca sp.....) *Schizoneura* sp. ....)	Cf. *Equisetites morenianus* Kurtz.	*	*	Species of cf. *Phyllotheca* as figured by Schmalhausen (79).	Cf. *Schizoneura paradoxa* (S. and M.)	

The conclusion to be drawn from the Vereeniging plants is that they belong to a flora which flourished in South Africa, India, South America, and Australia during some portion of the Permo-Carboniferous epoch. On the whole, it would seem probable that the age of the plant-beds corresponds most nearly with the Upper Carboniferous period as represented in Europe. It is of necessity difficult to attempt to express the geological age or homotaxy of South African beds in terms of the geological chronology of the Northern Hemisphere, but the close correspondence of some of the Vereeniging types with Indian and South American species points to their correlation with the Karharbari beds of the Lower Gondwana system. The occurrence of such types as *Sigillaria*, *Bothrodendron*, and *Psygmophyllum* shows a closer correspondence between the South African flora and that of the Northern Hemisphere than occurs in the Indian vegetation; we have evidence of an overlapping or commingling of the northern and southern botanical provinces * in South Africa and in South America that is not afforded by the Lower Gondwana floras of India and Australia.

* Zeiller (97).

IV.—*WITTEBERG SERIES.*

I do not propose to enter into a discussion as to the stratigraphy of the Witteberg beds:* the numerous examples of *Spirophyton* which they have afforded do not, in my opinion, supply a clue to their geological age. A small and obscure fragment of a Lepidodendroid plant, which is the only recognisable and undoubted fossil plant included in the collection, would be in accordance with the reference of the series either to the Carboniferous or Devonian period. Considering the relation to the Witteberg series to the rocks containing the species described in Part III. of this Memoir, it would seem probable that they belong rather to the Devonian than to the Carboniferous epoch.

LEPIDODENDROID PLANT.

(53a) A small and obscure impression on a quartzose rock showing crowded and spirally disposed projections. Too small and imperfect to determine. From Rooiberg, Breede River.

ROOTS (?)

The quartzose rocks in which the *Spirophyton* occurs contain also some radially disposed and comparatively deep grooves, which differ from the ridges and grooves of *Spirophyton* in being straight and few in number; they probably represent roots which spread into the sand from a central axis. The preservation is not sufficiently good to enable one to hazard a suggestion as to the nature of the plant to which they belonged, but they certainly differ from the typical *Spirophyton*, and should not be included under that head.

(44a) A large block of quartzite with a funnel-shaped depression on one face, the sides of which are marked by irregular deep grooves which may have been formed by radially disposed roots.

(45a, 47a, 50a) A smaller specimen showing at one end half of a conical elevation bearing radially arranged grooves; on the face of rock exposed in a longitudinal section through the apex of the conical elevation one sees indications of a central line or axis, from which iron-stained bands extend through the matrix. This specimen,

* See Feistmantel (89); Annual Report (99).

like 44a, 45a, and 47a, does not exhibit the typical *Spirophyton* characters.

Genus SPIROPHYTON, Hall.

(Probably of mechanical and not vegetable origin.)

Among the specimens from Cape Colony there are a few large blocks of hard quartzose rock containing well-marked impressions of the problematical fossil *Spirophyton* from the Witteberg sandstone, ½ mile N.E. of Touws River Station, from Zout Kloof, 3 miles E.S.E. of Ladismith and from the north bank of the Touws River at Letta's Kraal.

The Reports of the South African Geological Commission contain several references to the abundance of *Spirophyton cauda-galli* in the Witteberg quartzites;* it is mentioned as being particularly abundant towards the top of this series, and is regarded as a convenient and apparently trustworthy means of recognising the Witteberg beds.

In 1842 Vanuxem† published a figure of a "fucoid," which he described as occurring in great abundance in the so-called Cauda-Galli Grit of the Ithaca group, Madison County. Vanuxem's fossil was afterwards figured by Hall‡ under the name *Spirophyton cauda-galli* Van. as occurring in North American strata referred to the Devonian period, and described as a plant consisting of a slender axis bearing a thin and broad spirally disposed "phyllome." Hall, as well as several other authors, compared the fossil with certain recent Algæ. The authors of the Palæobotanical volume of Zittel's *Handbuch der Palæontologie* § include *Spirophyton* with other similar forms in the group Alectorurideæ; this group comprises examples ranging in age from Silurian to Tertiary strata. There can be little doubt that the fossils referred to Schimper's genus *Alectorurus* ‖ of Silurian age, as well as those included in such genera as *Cancellophycus* ¶ and *Taonurus* ** from Mesozoic strata, without mentioning others from Upper Palæozoic †† and Tertiary rocks, might equally well be designated *Spirophyton*. It is evident that Vanuxem's genus, whatever its nature may be, is met with in sedimentary rocks of almost all geological formations. Nathorst ‡‡ speaks of the Alectorurideæ as occurring in such a position in sedimentary strata as must

* Annual Reports (97), pp. 19, 56, 64; (98), pp. 16, 49, 61; (99), p. 35.
† Vanuxem (42), pp. 128, 177, figs. p. 128.
‡ Hall (63).
§ Zittel (90), p. 54.
‖ *Ibid.*, fig. 43, p. 55.
¶ *Ibid.*, p. 57.
** Heer (76), pl. xlviii.
†† Lesquereux (79), pl. A.
‡‡ Nathorst (86), p. 45.

lead to the conclusion that, if they be organic, they must have lived on the spot where they occur as fossils. But as they are found in deposits where they could have had no convenient support on which to grow, the opinion to which he is driven is that *Spirophyton* and allied forms are of mechanical origin and do not represent Algæ or other organisms.

Potonié* reproduces a figure of *Spirophyton eifeliense* originally published by Kayser† from Lower Devonian rocks; he states that by stirring sand in water he was able to produce an appearance like that of the typical *Spirophyton*. In an exhaustive memoir by Fuchs‡ *Spirophyton* and other problematical forms are discussed in detail; this author describes an Eocene specimen in the Pisa Museum having a diameter of 40 cm.; he deals also with Tertiary examples from the Flysch and elsewhere. Reference is also made to the well-known screw-like fossils from America§—the Devil's corkscrew or *Daimonelia*, and *Spiraxis*, described by Newberry, Barbour, James, and others; Fuchs expresses the opinion that these various fossils are all of similar nature and do not represent impressions of plants. He suggests that *Spirophyton* and similar markings may owe their origin to some animal, probably a worm, which produced a spiral cavity in sand or other sediment, and another comparison he makes is with the spawn-bands ("Laichbänder") of certain nudibranchs (*e.g.*, *Doris*).

The examination of the *Spirophyton* specimens from South Africa confirms my suspicion that this abundant "fossil" owes its origin to mechanical causes. *Spirophyton* has so extended a geological range that this fact alone makes one pause in describing it as a fossil alga; persistent types are well known to occur, but an organism with the persistence of *Spirophyton* can only be recognised as such on convincing evidence. The occurrence of this fossil in rocks, which are in some instances almost destitute of undoubted organic remains, is another fact to which some weight should be attached. But it is the nature of the specimens themselves that furnishes the strongest argument against the acceptance of *Spirophyton* as an organism. The strong and prominent ridges curving outward from a central point do not convey the impression of records that are likely to have been left by the thallus of an alga in a bed of sandstone; the occurrence of the fossils in a vertical position traversing several inches of a quartzose rock is a fact easier of explanation on the mechanical theory of their origin. My view is that these Witteberg *Spiro-*

* Potonié (99), p. 39.
† Kayser (72).
‡ Fuchs (95), p. 410.
§ Newberry (85); James (95), &c.

phytons have probably been formed by swirling water which has left an impress in the form of obliquely striated and prominent ridges (pl. xiv.) on the hardened sediment of an eddying stream that flowed through the sand by a narrow vertical channel. I ought to add that I have not made an extended examination of Spirophytons from other localities, but as regards the South African specimens my view is that they do not represent the remains of plants.

Plate XIV., fig. 1 (57a).

The drawing shows the surface-view of a specimen, 13 cm. by 12 cm., in which the *Spirophyton* characters occur on different levels of the rock, but with no apparent regularity. In the centre (*a*) there is an approximately cylindrical and obliquely placed cast, from which the curved ridges and grooves radiate over the surface of the stone, sloping slightly downward from the central point. This axis may well be the cast of a central channel in which the swirling water passed or flowed through the sand. As shown in the figure, the surface of the rock is very uneven; at *c* several prominent ridges are seen covered by numerous oblique secondary ridges. Similar obliquely striated and prominent ribs are shown also at *b* at a higher level. There is no trace of any carbonaceous matter. The strongly marked and prominent ridges form a striking feature, and cannot, I believe, be explained on the assumption that they have been formed by the impress of a leaf-like organ.

Plate XIV., fig. 2 (12a).

View of a specimen, 12 cm. broad, showing a portion of a *Spirophyton* impression. The centre from which the curving ridges spring was probably close to the left-hand end of the drawing, where the surface of the rock stands at a slightly higher level. The edge of the impression (right-hand side of the figure) is fairly well defined, and forms a definite boundary between the *Spirophyton* and the rock matrix. The surface is undulating, with occasional broad curved folds which are traversed by numerous parallel ridges less prominent than those shown in fig. 1. At *d* a few parallel ridges are seen following a course oblique to the general trend of the narrow ribs and grooves.

Other specimens: 1. A specimen from $\frac{1}{4}$ mile South of Ladismith, 13 cm. by 13 cm., showing a truncated prominence in the centre,

from which irregular ridges and grooves extend in double curves over the face of the rock, forming a figure reminding one of the lines of sparks given off from a rotating Catherine Wheel; surface features more obscure than in the figured specimens. The depth of the grooves and the prominence of the ridges are in themselves a weighty argument against the view that we have before us the impression of an algal thallus.

3. From Worcester; a small specimen similar to that shown in fig. 2; 403.

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EXPLANATION OF PLATES.

Plate I.

Onychiopsis mantelli (Brongn.).

Fig. 1. Natural size (428c). White River, Dunbrodie (Geelhoutboom)
,, 2. x 1½ (391c). ,, ,, ,,
,, 3. x 2 (407c). ,, ,, ,,
,, 4. x 2 (401c). ,, ,, ,,

Plate II.

Cladophlebis browniana (Dunk.).

Fig. 1. Natural size (343c). Near mouth of Bezuidenhout's R.
,, 1*a*. x 4 ,, ,, ,,
,, 2. Natural size (344c). ,, ,,
,, 2*a*. x 4 ,, ,, ,,
,, 3. x 3 (364c). ,, ,,
,, 4. Natural size (342c). ,, ,,
,, 4*a*. x 3 ,, ,, ,,
,, 4*b*. x 4 ,, ,, ,,
,, 6. x 1½ (361c). ,, ,,

Tæniopteris sp.

Fig. 5. Natural size (172d). Two miles east of Herbertsdale
,, 5*a*. x 1½ (193d). ,, ,,

Sphenopteris fittoni Sew.

Fig. 7. Natural size (249c). Near mouth of Bezuidenhout's R.
,, 7*a*. x 3 ,, ,, ,,
,, 7*b*. x 2 ,, ,, ,,
,, 8. x 2 (376c). ,, ,,
,, 8*a*. x 4 ,, ,, ,,

Plate III.

Zamites recta (Tate).

Fig. 1. Natural size (257c). Near mouth of Bezuidenhout's R.
,, 1*a*. x 2 (258c). ,, ,,
,, 2. Natural size (288c). ,, ,,
,, 3. ,, (A). ,, ,,

Plate IV.

Nilssonia tatei sp. nov.

Fig. 1. } Natural size (291c). Near mouth of Bezuidenhout's R.
,, 2. }

Cycadolepis jenkinsiana (Tate).

Fig. 3. Natural size (315c). Near mouth of Bezuidenhout's R.
,, 4. ,, (280c). ,, ,,
,, 5. x 3 (319c). ,, ,,
,, 6. Natural size (311c). ,, ,,

Plate V.

Onychiopsis mantelli (Brongn.).

Fig. 1. Natural size.
(Type-specimen of Tate; Museum of Geological Society of London, No. 11,114.)

Benstedtia sp.

Fig. 2. Natural size (292c). Near mouth of Bezuidenhout's R.

Zamites rubidgei (Tate).

Fig. 3. Natural size.
(Type-specimen of Tate; Geol. Soc. Museum, No. 11,109.)

Zamites morrisii (Tate).

Fig. 4. Natural size.
(Type-specimen of Tate; Geol. Soc. Museum, No. 11,108.)

Zamites africana (Tate).

Fig. 5. Natural size.
(Type-specimen of Tate; Geol. Soc. Museum, No. 11,110.)

PLATE VI.

Conites sp. *α*.

Fig. 1. Natural size (253c). Near mouth of Bezuidenhout's R.
,, 1*a*. x 5 ,, ,, ,,
,, 3. Natural size (298c). ,, ,,

Conites sp. *β*.

Fig. 2. Natural size (310c). Near mouth of Bezuidenhout's R.
,, 2*a*. x 2½ ,, ,, ,,

Araucarites rogersi sp. nov.

Fig. 4. Natural size (298c). Near mouth of Bezuidenhout's R.
,, 5. ,, ,, ,, ,,
,, 6. ,, (295c). ,, ,,
,, 7. ,, (300c). ,, ,,

Zamites recta (Tate).

Fig. 8. Natural size (298c). Near mouth of Bezuidenhout's R.
,, 9. ,, (328c). ,, ,,
,, 10. Considerably enlarged (*a*). ,, ,,
,, 11. x 1½ (342c). ,, ,,
,, 12. Natural size (286c). ,, ,,

Brachyphyllum sp.

Fig. 13. Natural size (299c). Near mouth of Bezuidenhout's R.
,, 18. x 3 (348c). ,, ,,

Planta incertæ sedis.

Fig. 14. Natural size (332c). Near mouth of Bezuidenhout's R.

Taxites sp.

Fig. 15. Natural size (182d). Herbertsdale.

Cladophlebis denticulata (Brongn.) forma *atherstonei*.

Fig. 16. Natural size (170d). Herbertsdale.
,, 17. x 1½ ,, ,,

Plate VII.

Thinnfeldia odontopteroides (Morr.).

Fig. 1. Natural size (21e). Kenigha River.

Stenopteris elongata (Carr.).

Fig. 2. Natural size (21e). Kenigha River.
,, 3. ,, (B). Stormberg.
,, 3*a*. ,, (B). ,,
,, 3*a*. Ultimate segment enlarged.

Callipteridium stormbergense sp. nov.

Fig. 4. Pinnules enlarged (x 2) (10). Kenigha River.
,, 5. Apex of frond (31e). ,,
Figs. 6, 6*a*. Natural size (39e). ,,
Fig. 6*a*. Pinnule enlarged (x 2).

Thinnfeldia odontopteroides (Morr.).

Fig. 7. Natural size (477d). Maclear village.
Figs. 8, 8*a*. Natural size (45e). Edward's Hope, Matatiele.

Plate VIII.

Thinnfeldia rhomboidalis Ett.

Fig. 1. and a fragment of *Stenopteris elongata* (Carr.) (C). Stormberg.

Callipteridium stormbergense sp. nov.

Fig. 2. Natural size (46e). Edward's Hope, Matatiele.

Baiera stormbergensis sp. nov.

Fig. 3. Natural size (x).

Tæniopteris carruthersi (Ten.-Woods).

Fig. 4. Natural size (1). Kenigha River.
,, 5. ,, (14e). ,,
,, 6. ,, (497d). ,,

Thinnfeldia odontopteroides (Morr.).

Fig. 7. Natural size (22e). Kenigha River.
,, 8. ,, (d). Cyphergat.

PLATE IX.

Phænicopsis elongata (Morr.).

Fig. 1. Natural size (C). Cyphergat.

Stachyopitys sp. (cf. *Sphenolepis rhætica*, Gein.).

Figs. 2, 2*a*. Natural size (12). Kenigha River.

Strobilites sp.

Fig. 3. Natural size (486d and 495d). Tina Drift.

Chiropteris cuneata (Carr.).

Fig. 4. Natural size (C). Cyphergat.

Schizoneura krassevi sp. nov.

Fig. 5. Natural size (308d). Matatiele village.
,, 6. ,, (487d). Tina Drift.

Thinnfeldia odontopteroides (Morr.).

Figs. 7, 8. Magnified fragments of cuticle showing stomata, &c.

Phænicopsis elongata (Morr.).

Fig. 9. Natural size (d). Cyphergat.
,, 10. ,, (69). Molteno.

PLATE X.

Neuropteridium validum Feist.

Figs. 1, 1*a*, 1*b*. Pinnate frond (XXII.). Vereeniging.
Fig. 1*a*. Pinnule approximately natural size (*a* in fig. 1).
,, 1*b*. ,, ,, ,, (*b* ,,).
,, 2. Basal portion of frond (XXVI.). Vereeniging.

Glossopteris browniana Brongn. var. *angustifolia*.

Fig. 3. Natural size (XXII.). Vereeniging.

Glossopteris browniana var. *indica*.

Fig. 4. Natural size (XXII.). Vereeniging.

Noggerathiopsis hislopi.

Fig. 5. Natural size (XX.). Vereeniging.

PLATE XI.

Bothrodendron leslii sp. nov.

Fig. 1. Natural size (XXI.). Vereeniging.
,, 1*a*. Scar slightly enlarged.
,, 1*b*. Portion *b* of fig. 1 slightly enlarged.
,, 4. Natural size (B).
Figs. 5 and 6. Natural size (XX.). Vereeniging.

Thinnfeldia odontopteroides (Morr.).

Fig. 2. Natural size (44e). Edward's Hope, Matatiele.

Stenopteris elongata (Carr.).

Fig. 3. Natural size (6). Kenigha River.

PLATE XII.

Psygmophyllum kidstoni sp. nov.

Fig. 1. Natural size (XXIII.). Vereeniging.

Glossopteris ?

,, 2. ?Rhizome and roots (XX.). ,,

PLATE XIII.

Glossopteris browniana var. *indica*.

Fig. 1. Secondary veins (x 2) (Z). Worcester Station.

Noggerathiopsis hislopi (Bunb.).

Fig. 2. Natural size.
,, 3. Imperfect leaf, natural size (XXV.). Vereeniging.
,, 4. ,, ,, (XXIV.). ,,

Gangamopteris cyclopteroides Feist.

Fig. 5. Natural size (A). Vereeniging.

PLATE XIV.

Spirophyton.

Fig. 1. Letta's Kraal, Worcester division.
,, 2. Zout Kloof, 3 miles E. of Ladismith.

Onychiopsis.

1.

×4

2a

×4 1a.

4.

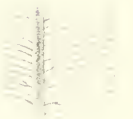
4a.

×3

5

4b

×4



×1½

6.

7a.

×3

×3

×2 7b

7

×4

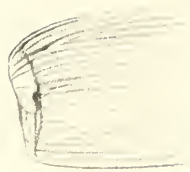


Fig. 1a.

Fig. 1.

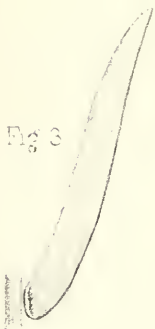


Fig. 3.

Fig. 2.

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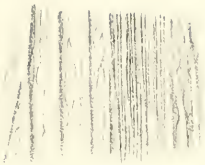
Zamites.

Fig. 1.



×3 Fig. 5

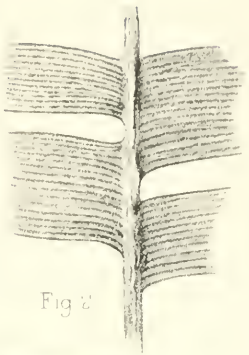


Fig. 2

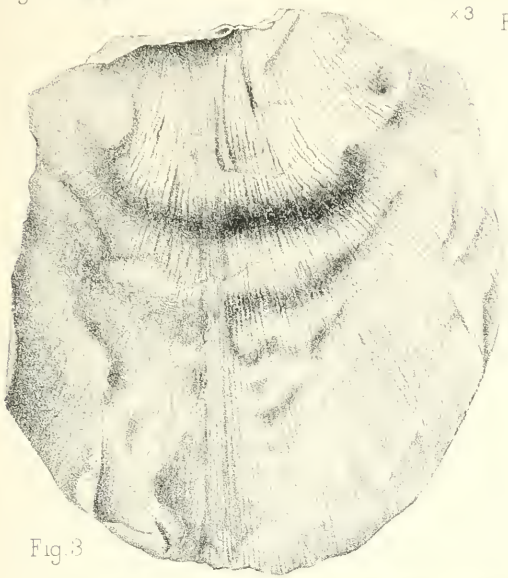


Fig. 3

Fig. 4

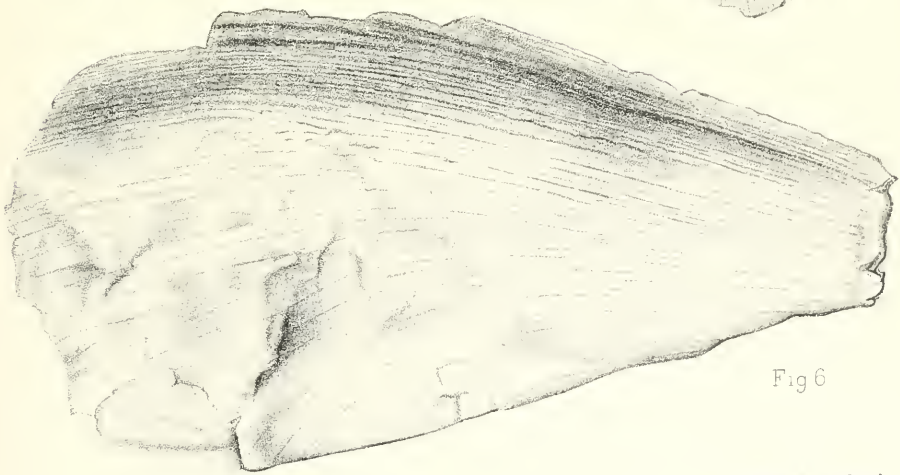


Fig. 6

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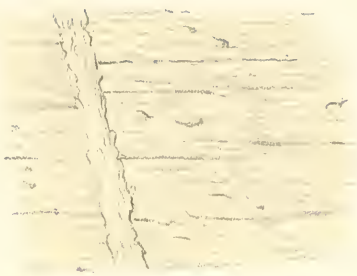
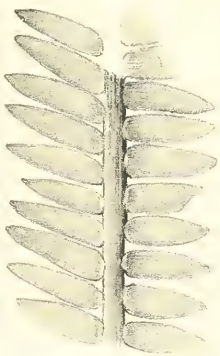
Cycadophyta

1.



2.

3.



4.

5.

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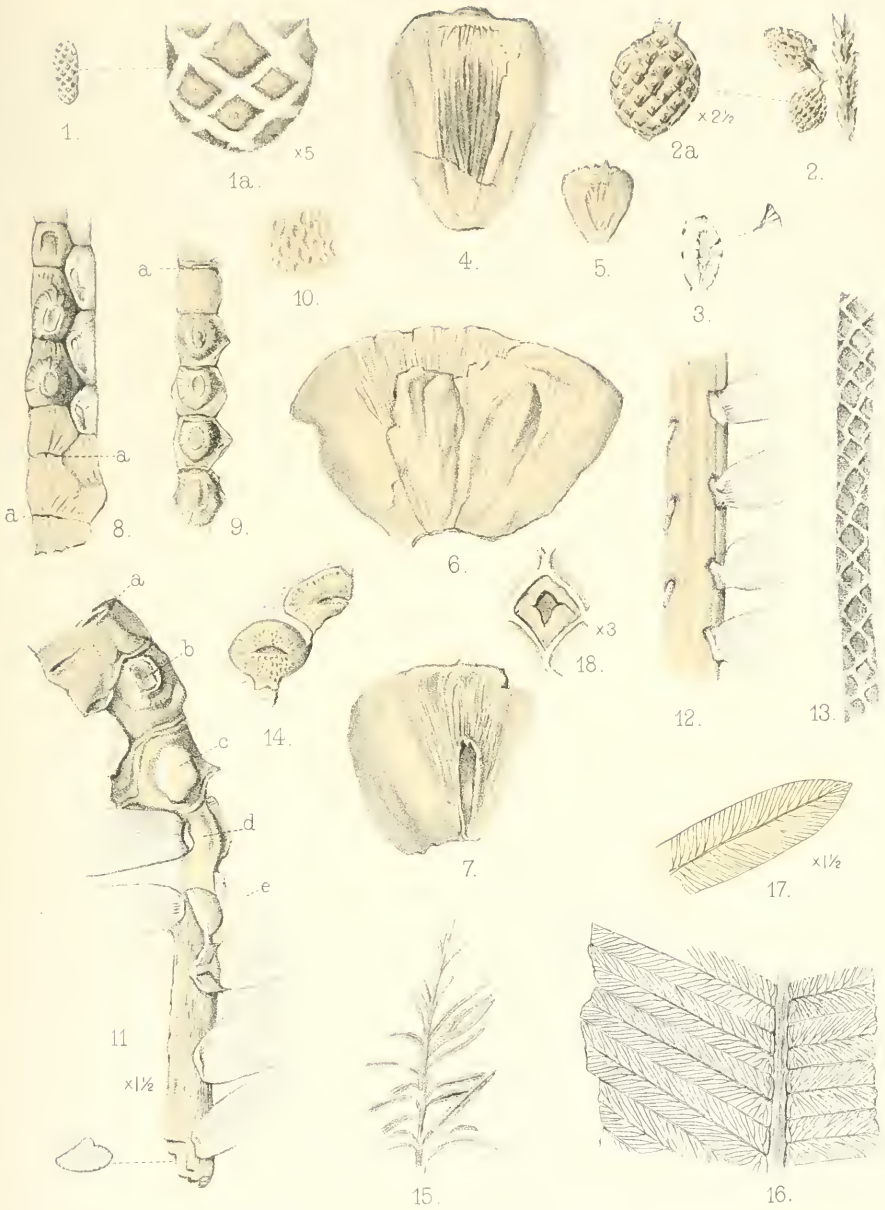
Cycadophyta etc



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Coniferales etc

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Ginkgoales, Filicales.

Equisetales etc.

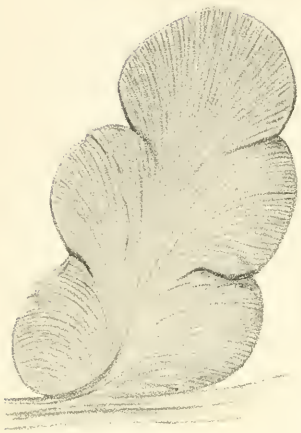
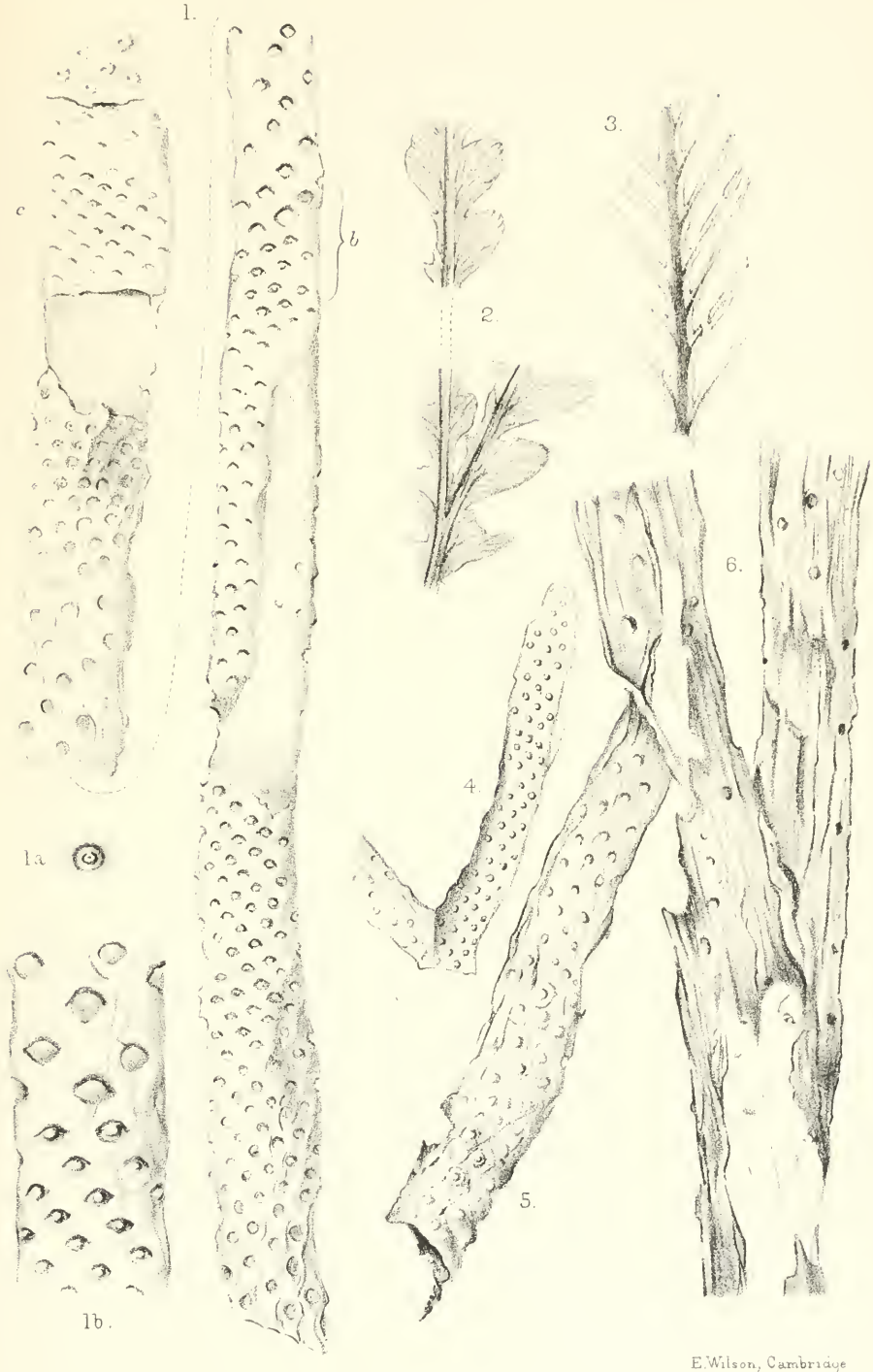


Fig. 1a.

Fig. 1b.

Fig. 2.

dium etc.



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Lycopodiales etc.

Fig. 1.

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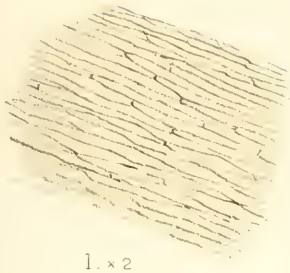
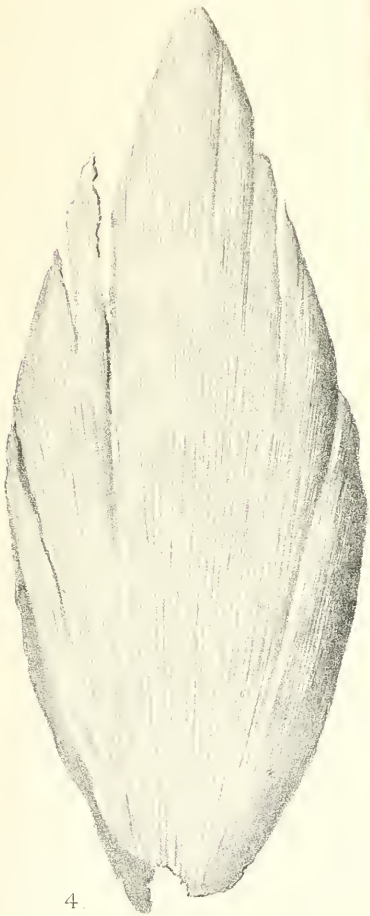
hyllum.



1. × 2

2.

3. - 1/5th



4.

5.

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Noeggerathiopsis etc.

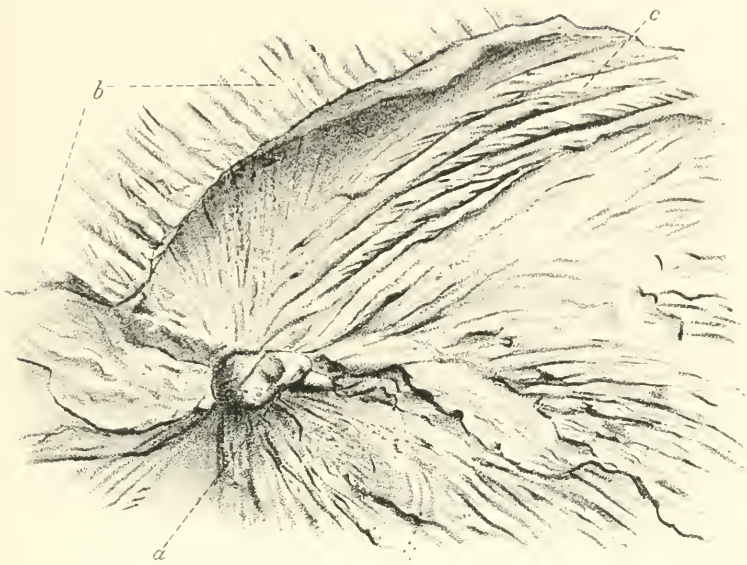

Fig. 1.

Fig. 2.

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Spirophyton.

Seward, A. C./Fossil flo
3 5185 000